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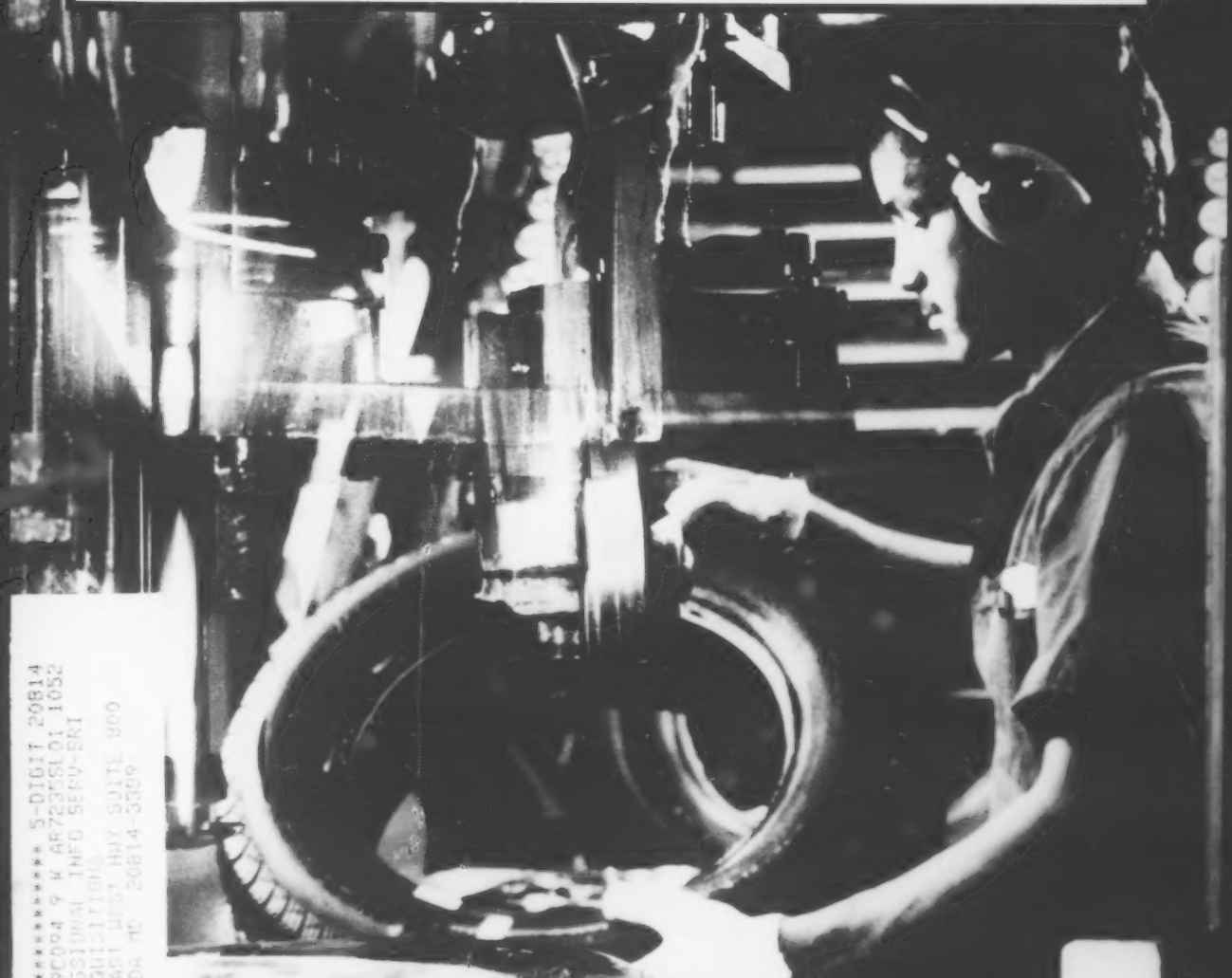
CHEMICAL & ENGINEERING NEWS

C&EN

AUGUST 29, 1994

NEW SYNTHETIC METHODS YIELD COMPLEX LINKED-RING MOLECULES PAGE 28



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# RUBBER CHEMICALS

Additives strive to meet more demanding product performance

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CHEMICAL & ENGINEERING NEWS

C&EN

AUGUST 29, 1994

## NEWS OF THE WEEK

■ Linus Pauling, who won the Nobel Prize in Chemistry for his work on chemical bonds and the Nobel Peace Prize for his efforts to end nuclear testing, is dead at 93. Page 4

■ An explosion and fire at Shell olefins plant in Norco, La., will further pinch U.S. ethylene supplies; no one was seriously injured. Page 5

■ Monsanto announces $1 million contest for development of practical method to recover ammonia from waste streams containing organics. Page 5

■ The 208th national meeting of the American Chemical Society attracted about 13,500 attendees to its myriad activities. Page 6

■ Top German chemical firms post better results for first-half 1994, spurred mainly by improved sales and profits abroad. Page 7

■ Synthesis of $C_{60}H_{12}$—"buckybowl"—by flash pyrolysis achieved by Louisiana State University researchers. Page 7

■ Chlorinated organic chemicals can be used and discharged without adverse effects, says a study commissioned by Chemical Manufacturers Association, fueling ongoing controversy. Page 8

COVER: Photo courtesy of Goodyear

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## BUSINESS

**Companies benefit from cooperative R&D agreements with federal labs,** but lack of federal funding and issues such as patent rights and competitiveness may slow collaborative work. Page 18

**The market for purified terephthalic acid continues to grow,** and producers respond with expansions that will boost global capacity 62% by 1998. Page 19

## GOVERNMENT

**Senate appropriations for federal R&D are up 1%** from the Administration's requested budget—NIST would receive major increase, with NSF, NIH, and Defense seeing more modest gains. Page 23

**EPA proposes a threshold exemption for reporting releases and transfers of toxic chemicals** in an attempt to reduce paperwork for the agency and chemical industry. Page 25

## SCIENCE POLICY

**Japan has a new national concern**—the drying up of the pipeline of new technical professionals—as its youth display a lack of interest in science and technology. Page 26

## SCIENCE/TECHNOLOGY

**New template-directed syntheses of elegant linked-ring macromolecules** called catenanes are leading researchers to propose that preparation of interlocking ring polymers may be near. Page 28

**Iron phthalocyanine complexes encapsulated in zeolite crystals** are the basis for a new synthetic catalyst system that mimics the structure, function, and activity of P450 enzymes. Page 34

## EDUCATION

**Technological advances and new instructional methods leading to changes in undergraduate chemistry curricula** were the focus of a recent ACS Division of Chemical Education conference. Page 35

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**Demands for tougher, more resistant, better performing rubber products, as well as health and environmental concerns, drive development of high-performance rubber chemicals and additives.** Page 11

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# LETTERS

## Regulation for the public good

Several important pieces of environmental legislation are up for renewal by Congress. These include the Clean Water Act, the Safe Drinking Water Act, the Endangered Species Act, and Superfund. These acts should be strengthened, rather than weakened, as suggested by some businesses, municipalities, and landowners who wish to continue to externalize some of their costs at the expense of the general public. Your report on the Business Roundtable (C&EN, July 4, page 15) puts it in this group.

Regulations usually result from failures in our market-based system that lead to disasters and abuses that have an impact on the good of the general public. There have been three incidents in northern Delaware in the past two months. A vessel broke allowing the release of about 500 lb of chlorine into the air, two tanks of oily ballast water were destroyed by fire at the Star Enterprise refinery, and the Salem nuclear power plant had an emergency alert.

These incidents could have been much more serious. Should the regulations covering these businesses be beefed up to prevent recurrences? If businesses and municipalities were self-policing and avoided such problems, there would be much less inclination to regulate.

The report of the Business Roundtable deals in generalities, using words that imply that the present system is costly and inefficient. It tells what industry is spending to comply but doesn't mention what is needed to correct the problems. (It doesn't mention the many jobs and businesses that have been created by the cleanup.) The laws have encouraged innovation to find less polluting processes. The main loss in innovation has been the curtailment of exploratory research as a result of corporate downsizing. The lack of growth may be due to failure to modernize. An example is lack of adoption of continuous casting by the U.S. steel industry some years ago.

The concept of cost-benefit analysis has been twisted to make environmental compliance look very expensive. The costs to the general public are often left out of industry's calculations. The loss of jobs when the fishery downstream is destroyed, a child's asthma from air pollution, the loss of biodiversity from the extinction of species, decreased crop yields, and the loss of recreation close to home need to be included. However, it is very difficult to put dollar signs on some of these.

The report also mentions unfunded mandates imposed by federal laws on state and local governments. All levels have a shared responsibility to fund environmental legislation. Perhaps we should return to the funding formula used in the pre-Reagan years. In a case of illnesses of thousands of people from Cryptosporidium in the Milwaukee water supply, it would seem that the local citizens should be happy to put up the money for an improved water supply. Regulation at the federal level has the advantage of providing a level playing field, so that a business can't compete more successfully by moving to a locality where pollution laws are weaker.

No one would say that we have found the best way to regulate for the good of the general public. Market-oriented regulations and performance standards are being implemented. One of the most successful approaches has been the law requiring that industries report their toxic emissions. When a company sees its name in the local paper as the number-one polluter in the area, it finds time to fix those leaky valves and, sometimes, to reexamine the whole process in the plant to look for possible improvements.

Many companies and municipalities make an earnest effort to clean up. However, there are others that have "greened" primarily in their public relations departments.

**Albert S. Matlack**
*Hockessin, Del.*

## Put DEA in charge of tobacco

The Commissioner of the Food & Drug Administration has been suggesting that tobacco be placed under FDA control as a drug (C&EN, June 27, page 5), and a letter (C&EN, July 25, page 5) suggests that regulation of tobacco be transferred from

### Correction

• Aug. 22, page 7: In the discussions between American Cyanamid and SmithKline Beecham, Cyanamid's prescription drug and consumer-brand businesses and SmithKline's vaccine and animal health businesses were the businesses under consideration to be swapped.

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# Rubber Chemicals And Additives Adapt To Changing Demands

■ ***Customers' calls for rubber products with improved durability and heat resistance lead to better rubber chemicals***

**Marc S. Reisch,**
C&EN Northeast News Bureau

Rubber products today must last longer under higher temperature conditions than they did just a few years ago. They must perform under greater environmental stress and still look good. And they must compete against plastics and other materials.

But while a compounder's choice of any number of synthetic or natural rubber polymers will influence the ultimate durability and performance of a rubber article, such as a tire or an automotive radiator hose, processing chemicals and additives are decisive elements. Without processing chemicals and reinforcing additives, such as carbon black and silica, rubber manufacture as we know it would not be possible.

Rubber chemicals initiate the cross-linking of both natural and synthetic elastomers in a process (generally requiring sulfur) called vulcanization. Some additives directly affect a rubber article's durability, by protecting it from the degrading effects of oil, moisture, air, or ozone. Other additives lubricate rubber for processing, allow for easier release from molding equipment, or initiate the formation of air bubbles in a compound to produce sponge rubber for gaskets.

Trends affecting rubber chemicals have led to the development of compounds that reduce worker exposure to suspected nitrosamine carcinogens, allow the production of more heat-resistant compounds, and enhance tire durability. As a class, rubber chemicals are a disproportionately small part of a rubber article. Rubber compounders use an average of just 4.4 lb of rubber-processing chemicals per 100 lb of rubber.

On the other hand, rubber compounders may load rubber for tire use with the reinforcing additive—carbon black—at rates as high as 75 lb per 100 lb of rubber. Carbon black acts not just as a filler; it is also a performance additive that imparts strength and toughness to a tire. Manufacturers have developed new grades of carbon black for use under higher temperatures than previously were customary, for instance, for under-the-hood automotive hoses. Tire makers are also substituting various amounts of silica for carbon black, as they construct passenger car tires intended to last 80,000 or even 100,000 miles.

*Goodyear technician studies tread design.*

Rubber products can be separated into two major categories, with sales valued at more than $18 billion: fabricated rubber products and tires. The U.S. International Trade Administration (ITA) estimates the value of synthetic rubber produced in the U.S. in 1993 at about $4.5 billion, but the estimated value of fabricated rubber products produced from those synthetics with the addition of natural rubber is $6.7 billion. The category includes not only elastomeric roofing, rubberized fabrics, geomembranes to line landfills, and conveyor belts but also a significant number of automotive-related items such as belts, hoses, and gaskets. ITA values 1993 tire shipments at $11.4 billion.

Much of the increase in value added to raw synthetic and natural rubber to make rubber products results from the physical process of compounding and then forming rubber in tire molds and hose and sheet extruders. Many rubber items contain reinforcing steel or polyester fiber, which adds performance—as well as cost—to an item's manufacture. But the addition of rubber-processing chemicals provides advantages out of proportion to their cost. Industry sources estimate that U.S. compounders spend about $500 million on rubber chemicals annually. Thus, rubber chemicals, which not only affect rubber's performance but also allow cross-

## Rubber requires additives for best performance

Crude rubber has few applications in its raw state and requires a number of chemical additives and fillers to modify its hardness, strength, and toughness. It also needs additives to increase resistance to heat, abrasion, oil, ozone, oxygen, and solvents. The additives fall into 10 categories:

Accelerators: Used with sulfur to shorten rubber cure time.

Antioxidants: Improve service life of rubber exposed to air, heat, and light.

Antiozonants: Protect cured rubber against degradation from atmospheric ozone.

Blowing agents: Allow formation of cellular structures to produce sponge rubber.

Fillers: Materials such as clay, whiting, and diatomaceous earth used to add weight and bulk.

Pigments: Impart color to rubber articles.

Reinforcing agents: Add strength and toughen rubber. Carbon black is the most important reinforcing agent.

Retarders: Lengthen time before rubber cures to prevent "scorching"—that is, premature curing.

Softeners and plasticizers: Shorten mixing time and help disperse compounding agents.

Vulcanizing agents: Initiate cross-linking of polymer chains to cure rubber.

linking of rubber compounds, represent less than 3% of the $18 billion value of rubber products.

C&EN estimates that the domestic rubber industry will use about 304 million lb of organic processing chemicals in 1994, compared with 297 million lb in 1993. Of 1994 consumption, 59% by weight will be antioxidants and antiozonants, 34% will be vulcanization agents and accelerators, and 7% will be other chemicals such as blowing agents. Industry sources suggest that rubber processors worldwide use 1.4 billion lb of rubber chemicals, worth some $2.4 billion. Industry overcapacity, they say, had led to lower prices of rubber-processing chemicals worldwide.

More than 20 U.S. companies produce about 200 or so substances that over 1,000 U.S. rubber product manufacturing plants use to make rubber compounds. Seven of those rubber chemical producers are diversified manufacturers, which account for more than 80% of U.S. rubber chemical sales. The seven companies are St. Louis-based Monsanto, which probably is the largest U.S. rubber chemicals producer, with about 35% of the market; Uniroyal (Middlebury, Conn.); Goodyear (Akron, Ohio); BF Goodrich (Akron); Miles (Pittsburgh), the U.S. affiliate of Germany's Bayer; R. T. Vanderbilt (Norwalk, Conn.); and Akzo Nobel (Chicago). The largest U.S. rubber chemical producers—Monsanto and Uniroyal—are also global producers, with products manufactured and shipped worldwide. Several other companies also participate in the U.S. rubber chemicals market: Phillips (Bartlesville, Okla.), Elf Atochem (Philadelphia), Cytec (West Paterson, N.J.), Hampshire Chemical (Lexington, Mass.), and Sartomer (Exton, Pa.).

A host of distributors also serves rubber compounders. R. T. Vanderbilt is not only a manufacturer but also a major distributor. C. P. Hall, based in Chicago, is a large distributor and rubber chemicals producer. Over the past few years, Hall has acquired Morton Rubber Chemicals and product lines from Union Carbide and American Cyanamid. Other large distributors include Akrochem Corp. (Akron, Ohio), Harwick Chemical (Akron), and H. M. Royal (Trenton, N.J.)

According to Ron Walters, Monsanto's worldwide marketing director for its rubber and process chemicals business, Monsanto has been manufacturing rubber chemicals since 1929. Today, the company has plants in the U.S., Canada, South America, Europe, and Asia. A separate unit, Monsanto Instruments & Equipment, based in Akron, makes rubber test equipment for the industry. Walters believes that Monsanto has an edge over other rubber chemicals makers, because the company's rubber test equipment is so widely used as a standard for measurement in the industry.

Walters says Monsanto has the largest capacity for making rubber chemicals in the U.S. but, like its competitors, does not specify Monsanto's capacity. The company produces four major categories of rubber chemicals: accelerators, antidegradants, vulcanization inhibitors, and specialty additives. Accelerators produced by Monsanto include sulfenamides, sulfenimides, and thiazoles.

A few years ago, most producers of rubber vulcanization accelerators dropped many of the sulfenimides they produced, because they react with airborne nitrogen oxides to become potentially carcinogenic nitrosamines. With prompting from the German government, the rubber chemicals industry was concerned that concentrations of nitrosamines would not only be too high in rubber factory air but also could affect air quality in tire warehouses and in car trunks where the spare tires sit. Monsanto's Santocure TBSI is the only sulfenimide now widely used in the rubber industry, says Walters. TBSI is a unique vulcanization accelerator, he says; it performs like a secondary-amine-based accelerator but without the potential to form nitrosamines.

Another important product, says Walters, is a hybrid cross-linker, hexamethylene-1,6-bis(thiosulfate), which helps rubber products retain their physical properties during both cure and service and also promotes bonding between rubber and brass-plated steel. Sold under the tradename of Duralink HTS, the product is widely used in tire manufacture.

As the U.S. economy has grown over the past two years, Walters says Monsanto has seen a slight increase in the sales of its rubber-processing chemicals in the U.S. But although many observers might think that increased auto production would necessarily increase rubber and rubber chemicals consumption, Walters says that it is actually more important to track how much people drive their cars and trucks. In the U.S., Europe, and other developed parts of the world, "it's all the same to us," says Walters; new car tires and older car replacement tires use the same amount of rubber chemicals, he points out.

New motor vehicle production (which in the U.S. was up 17% to more than 7 million units at the end of July, compared with the same period a year ago) means something more in the

Asia-Pacific region. There, most people are acquiring cars for the first time, says Walters. Market growth for rubber and rubber chemicals in Asia-Pacific slowed from double-digit growth before 1990 to high single-digit growth more recently. In contrast, the U.S. is now in the low single-digit growth area, market growth having been static between 1990 and 1991.

Degussa photo

Consumption of rubber chemicals worldwide also has been affected by the falloff in demand from countries that once were part of the Soviet Union or its close allies in Eastern Europe. Those countries once consumed 15% of world rubber, Walters estimates, but now they consume only about 5%. As a result, some rubber chemicals produced in countries such as the Czech and Slovak Republics are going into the world market.

Because of that new competition, and the decline in demand for rubber from the Commonwealth of Independent States and Eastern Europe, Walters acknowledges that worldwide there is more supply than demand for both rubber and rubber chemicals, and as a result, prices of rubber chemicals have declined. Because of some recent strengthening in rubber demand in the U.S. and signs of economic recovery in Europe, Walters says Monsanto has announced price increases for accelerators, quinoline-based antiozonants, and other products. He hopes the increases will stick.

Anthony M. Luxedor, rubber chemicals marketing director for BF Goodrich, says the company has been squeezed between higher prices for raw materials and an inability to pass along increases in rubber chemical prices to customers. Goodrich produces rubber chemicals only in the U.S. but sells them to other parts of the world. Luxedor attributes the price problem to competition not just from Central Europe but also from producers in Western Europe who have sought to sell products overseas during the recent recession in Europe.

Goodrich produces a number of amine- and phenolic-based antioxidants, used primarily to protect rubber from the degrading effects of heat. It produces phenolic phosphite to stabilize raw rubber during processing, protecting it from crusting on the surface. And the company also produces various thiazole and sulfenamide accelerators. The latter is not a contributor to the problem of airborne nitrosamines.

Uniroyal's Peter D. Welch, rubber chemicals business director, also acknowledges pressure from the automotive market to reduce costs, thereby pushing rubber chemical prices down. However, volume sales have been "not bad" over the past year. Demand for rubber chemicals is doing "rather well" in North America. Welch ranks Uniroyal second among U.S. rubber chemical producers, after Monsanto, and either second or third worldwide, after Monsanto and about on a par with Bayer.

Welch says that Uniroyal produces accelerators (based on aldehyde amines, dithiocarbamates, thiazoles, thiurams, and others); secondary-amine-based, phenolic-based, and other antioxidants; and nitrogen-based blowing agents. The company recently signed a letter of intent to expand in Eastern Europe via the purchase of Istrachem in Slovakia. Uniroyal's sales of rubber chemicals are split between the U.S. and overseas, Welch says, and markets outside the U.S. are growing faster. As a result, the company plans more efforts overseas. "Our customers are globalizing and we have to do the same," he says.

Uniroyal recently added a new thiuram-based accelerator, which reduces nitrosamine formation, to its line of rubber chemicals. Along with sulfenamide and thiazole accelerators, Uniroyal's new accelerator, tradenamed Benzyl Tuex, replaces tetramethyl thiuram monosulfide, tetramethyl thiuram disulfide, and tetraethyl thiuram disulfide, which form detectable amounts of nitrosamines. Benzyl Tuex also helps prevent the breakdown of natural cured rubber, says Welch.

***Tire distributor employees check inventory (left), and Goodyear engineer measures tire pressure (below).***

Akzo Nobel is planning to introduce a rubber chemical that also prevents rubber breakdown. The company's marketing director for the rubber chemicals group, Bob Bradley, says that in September Akzo Nobel hopes to introduce a new product to prevent the delamination of rubber tread from tire carcasses. Delamination is an annoying and frequently dangerous breakdown of rubber under heat and stress. Bradley hopes that the new rubber chemical will reduce or eliminate the rubber tread that litters interstate highways. He declines to describe the nature of the new proprietary product, which he calls an "antireversion agent." The product—tradenamed Perkalink 900—promises not only to help maintain rubber cure but also to allow increased manufacturing productivity through higher temperature curing.

In addition to its planned offering of Perkalink 900, Akzo Nobel offers a broad range of rubber chemicals. Worldwide, Bradley says Akzo Nobel probably ranks fourth among rubber chemicals suppliers in the U.S., after Monsanto, Bayer, and Uniroyal. Akzo Nobel produces cross-linking peroxides and insoluble sulfur (which aids in curing rubber) in the U.S. The company offers a range of accelerators including thiazole-, sulfenamide-, thiuram-, and dithiocarbamate-based products and antidegradants including diamine- and diphenylamine-based products from its overseas plants.

Bradley says the 2-mercaptobenzothiazole accelerator plant the company originally hoped to build in Le Moyne, Ala., by 1991, is still in the planning stages. Engineering for the plant is almost complete, and the company plans to apply for environmental permits in September or October.

Peroxide-cured rubber is seeing increased demand from auto manufacturers, notes Bradley. As car manufacturers extend warranties, they need hoses and rubber for under-the-hood applications that last longer in engines that run hotter and at higher revolutions per minute than they did a number of years ago. As a result, more peroxide-cured polychloroprene is in demand for auto use, he says. However, industry sources estimate that only about 5% of rubber is cured with peroxide. The bulk is still cured with sulfur.

According to Goodyear's applications R&D section head, Don E. Miller, Goodyear produces rubber chemicals in the U.S. and Europe that it uses for in-house tire and rubber product manufacture and also sells to customers. The company produces antioxidants and antiozonants. It has produced accelerators and vulcanizing agents, but it is in the process of shutting down part of its Niagara Falls, N.Y., complex where those compounds are produced because of environmental problems.

Miller says the company's *p*-phenylenediamine grades of antioxidants and antiozonants are industry mainstays, because they provide resistance to flex fatigue in tires and conveyor belts and add to product longevity at attractive prices. Sold under the tradename of Wingstay 100 and 200, they also are good heat stabilizers, he says. Goodyear also produces phenol-, diphenylamine-, and modified thioester-based antidegradants.

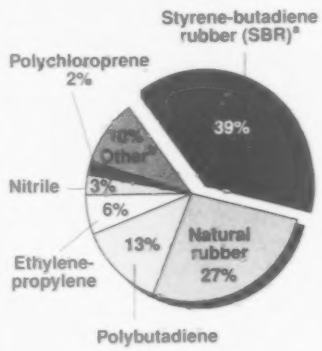
Some companies produce more limited lines of rubber chemicals. Phillips and Elf Atochem both produce mercaptans. Compounds like *n*-dodecyl mercaptan and *tert*-dodecyl mercaptan help control viscosity in synthetic rubber such as styrene-butadiene and polychloroprene, says Phillips specialty chemicals manager Mary Jane Hagenson. Elf Atochem also produces a line of accelerators based on alkylphenol disulfide. Vicki L. Quinn, Elf Atochem marketing manager, says that the company's alkylphenol disulfide product line lends heat- and age-resistant properties to rubber, particularly chlorobutyl rubber.

Cytec, the recent spin-off from American Cyanamid, sells a line of hexamethylmethoxymelamine under the tradename Cyrez; the product helps bond brass-coated steel to rubber, is a reinforcing agent in tire sidewalls, and aids rubber-to-rubber adhesion between tire layers. Cytec business manager Gene Cirilis says that Cyrez is an advanced resin technology that competes with cobalt and cobalt salts with high sulfur content for wire adhesion in rubber.

Sartomer, the resins division of French chemical company Total, sells a line of acrylic materials used in peroxide-cured rubber. Al Tuccio, Sartomer's marketing manager based at the company's U.S. sales office in Exton, Pa., says that as automotive manufacturers insist on better performance, demand for rubber cured with peroxide and acrylic coagents will grow. Most of the acrylic coagents supplied by Sartomer are based on trimethylolpropane trimethacrylate.

The coagents not only enhance rubber-to-metal adhesion but also improve compression set, hardness, dynamic properties such as resilience, and stress-strain properties. They also provide additional benefits, he says, in the form of water, oil, and chemical resistance. Tuccio admits, though, that acrylic coagents as well as peroxide cure agents are more expensive than sulfur-based systems and, as a result,

**SBR is most widely used type of elastomer**




1993 total U.S. rubber consumption = 8.4 billion lb

a Includes solid, latex, and carboxylated forms. b Includes isoprene, copolymers of isobutylene and isoprene, and other rubber. Source: International Institute of Synthetic Rubber Producers

**Tires continue to dominate U.S. rubber shipments**

Source: U.S. International Trade Administration

have met some resistance in the marketplace.

Besides the rubber chemicals used to enhance natural and synthetic rubber performance, carbon black, produced largely from oil, is an important additive for many rubber products. When added to tire rubber, it improves rubber's resistance to tearing, abrasion, and flex fatigue and also increases traction and durability. According to a recent study, "World Carbon Black," by industry consultant company Freedonia Group, a tire would last less than 5,000 miles without the addition of carbon black.

Freedonia, based in Cleveland, Ohio, estimates U.S. carbon black consumption at nearly 3.1 billion lb in 1993. Industry sources value that consumption at about $700 million. Worldwide, Freedonia estimates carbon black demand at 13.2 billion lb, equivalent to a global market of about $3 billion. Major worldwide carbon black producers include Cabot (Boston), Degussa Corp. (Ridgefield Park, N.J.), and Columbian Chemicals (Atlanta). In the U.S., at least three others are important producers: J. M. Huber (Edison, N.J.), Sid Richardson Carbon & Gasoline (Fort Worth), and Witco (Greenwich, Conn.).

Overall, carbon black consumption has tended downward in recent years, because smaller cars use smaller tires, and at least in the U.S., lower highway speed limits—55 mph—have prolonged wear. In addition, long-lasting radial tires have lengthened the time between tire replacements. But recent growth in the market for tire and industrial rubber may increase carbon black consumption in the future.

However, Freedonia's report cautions that tire makers are beginning to replace some carbon black with silica to improve tire rolling resistance and tire mileage rating and to decrease auto fuel consumption. But some manufacturers are prepared to face the challenge a real slowdown in carbon black consumption would pose. Carbon black manufacturers Huber, Cabot, and Degussa also can supply silica to tire makers.

Monsanto photo

*Chemicals fortify under-the-hood hoses and belts.*

According to Reinhard Stober, vice president and general manager for Degussa's carbon black division, weak demand for carbon black between 1989 and 1991 and then a price war among carbon black producers in 1992 and 1993 hurt carbon black producers' profitability. But demand for carbon black has improved along with the U.S. economy, and U.S. producers have been "sold out" since the beginning of this year, says Stober. Still, carbon black feedstock oil costs have risen, and recent increases in carbon black prices have only helped Degussa cover higher environmental costs. The company hopes to increase prices again this year. In any event, says Stober, the company has been caught between the fuel market and powerful buyers in the rubber tire industry, and so it has been "forced" to earn profits through improvements of process efficiencies.

Degussa's Stober thinks that tire carbon black consumption will grow at about 1.5% per year in the foreseeable future and not the 2 to 2.5% per year that industry consultants project. The slower growth is due to increased use of silica in rubber tires. But Degussa does not expect to lose out because of the increased use of silicas. According to Ken Cwick, vice president and general manager of Degussa's silica division, the company holds several patents covering the use of Degussa's proprietary silane in combination with the company's silica and carbon black to help tire manufacturers develop a product that achieves better rolling resistance while maintaining abrasion resistance and traction.

Cwick says that U.S. tires currently consume about 100 million lb of precipitated silica. Silica use will grow at a faster rate than overall tire rubber growth, because "everyone wants better fuel efficiency, longer tread life, and safer tires." Cwick says Degussa is prepared to aid the shift to improved tires.

Kyle Wendel, marketing director of Cabot's industrial rubber black business, agrees with Degussa's managers that, although demand and pricing for carbon black has improved in the U.S., the price increases have not been enough to counter higher production costs. However, he sees real growth and profit opportunities in supplying carbon black for industrial rubber products. Last month, Freedonia completed a report, "Industrial Rubber Products," which projects an annual growth of more than 6% for production of industrial rubber products in the U.S. between 1993 and 1998. Industrial rubber products include belts, hoses, elastomeric roofing, sheeting, and geomembranes for lining landfills or ponds.

New grades of carbon black will help improve industrial rubber's durability and performance at a competitive price, says Wendel. For instance, the company's carbon black product—tradenamed Sterling 1120—allows rubber to deliver good tensile strength at high loading in molded rubber products. The company's 6740 carbon black offers superior tear strength and surface appearance for extruded window channels and weather stripping.

Specialty carbon black for industrial rubber can enhance the high-temperature performance of an under-the-hood automotive hose, says Cabot applications development manager Steven Monthey. The company's carbon blacks can be especially effective in combination with high-temperature-resistant fluoroelastomers, because the addition of carbon black can lower the final cost of the fluoroelastomer part.

Many of the new carbon black grades are not simple "drop-ins" (replacements) for standard grades of carbon black, says Wendel. Customers will frequently have to reformulate their rubber compounds with the new specialty carbon blacks, he says, and the company's Norcross, Ga., applications development lab is ready to assist Cabot's customers in that effort.

Confident of the potential for specialty industrial-rubber-grade carbon blacks, Cabot currently has a new carbon black reactor line planned for its Sarnia, Ontario, facility, scheduled to operate in 1995. Carbon black is often considered a mature industry, but Cabot is trying to change that perception, says Wendel.

Although carbon black and rubber chemicals are widely regarded as mature industries, that perception should not imply that new developments never happen in these areas. The use of silicas in longer lasting tires may change demand for carbon black, but industrial carbon blacks, such as those developed by Cabot, may help generate new markets for specialty carbon blacks. Rubber chemical producers also do not function within a vacuum and so have to respond to health and environmental concerns by coming up with alternatives to compounds that form potentially harmful airborne nitrosamines. And as rubber performance expectations change, particularly for automotive use, rubber chemical producers have to react by creating product variants that enhance rubber durability and heat resistance. □

**Antidegradants are largest class of rubber chemicals**

| U.S. consumption, millions of lb | 1992 | 1993 | 1994[a] | 1998[a] |
|---|---|---|---|---|
| Antidegradants | 168.4 | 175.5 | 179.8 | 196.8 |
| Accelerators | 97.2 | 101.3 | 103.7 | 113.5 |
| Miscellaneous | 19.4 | 20.3 | 20.7 | 22.7 |
| TOTAL | 285.0 | 297.1 | 304.2 | 333.0 |

a Projections. Source: C&EN estimates

**Tires account for most carbon black use**

| U.S. consumption, millions of lb | 1993 | 1998[a] | 2003[a] |
|---|---|---|---|
| Tire rubber | 2,260 | 2,503 | 2,701 |
| Nontire rubber | 639 | 739 | 837 |
| Other[b] | 267 | 309 | 353 |
| TOTAL | 3,166 | 3,551 | 3,891 |

a Projections. b Includes uses in plastics, printing inks, and paints and coatings.
Source: Freedonia Group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# Companies find benefits, and barriers, in cooperative R&D with federal labs

**Ann M. Thayer,**
C&EN Northeast News Bureau

Facing cutbacks in research funding, chemical industry managers have found a new way to leverage resources through cooperative R&D agreements (CRADAs) with federal laboratories. These agreements are meant to spur the transfer of technology between federal labs and U.S. industry. Once a company has made a link with a federal lab, new opportunities and means for collaboration, contracting, or licensing often arise. But though deemed successful at the technical and technological levels, CRADAs have not been a panacea. And it is still too early in the program's life to know if the agreements will produce many tangible new products.

The number of CRADAs between industry and U.S. government labs has burgeoned. For example, CRADAs signed with Department of Energy labs since mid-1991 reached 974 by the end of July 1994. The total value of these DOE CRADAs is more than $1.9 billion. Another 466 CRADAs have been set up by the National Institute of Standards & Technology (NIST) since 1988, and the National Institutes of Health (NIH) has had 206 since 1986.

By the sheer numbers alone, it would seem that industry is finding the national labs accessible for R&D collaborations. And in general, companies are gaining access to federal labs, with just a few snags still remaining in the process. Chemical firms have been actively pursuing CRADAs, with several major companies, including Dow Chemical and DuPont, listed among DOE's top "repeat customers." Among other chemical producers involved with CRADAs are AlliedSignal, Olin, Rohm and Haas, W. R. Grace, and Union Carbide.

Clear government mandates directing technology transfer have caused CRADA activity, especially with the DOE labs, to pick up since 1990. And experience gained in negotiating CRADAs in the past few years has made the process go much more smoothly, say several government lab and chemical industry R&D and technology transfer managers interviewed by C&EN. Issues, they say, that centered on intellectual property, proprietary information, competitiveness, and bureaucratic delays have been better addressed.

"Getting CRADAs into place was a painful process at first," says Theodore Tabor, manager of cooperative research for Dow Chemical. "I believe it's gotten better [as] both the federal labs and industry have begun to learn how to work with one another." Dow currently has about 12 CRADAs with five national labs and with NIST in areas ranging from advanced materials to polymer processing to biosensors. Dow has another six agreements in various stages of negotiations, he adds.

The company's total investment in the agreements is about $5.9 million, or about 56% of the combined, cost-shared value of the CRADAs. Dow's contribution, like most industry cost sharing, is predominantly "work-in-kind," rather than actual cash, funding. Government labs can contribute personnel, equipment, facilities, and other resources but not funds.

"For a company Dow's size, I envision that interactions with the federal labs will continue to grow, not by leaps and bounds, but they will grow," says Tabor. "But I certainly don't envision this being a major push for the company. Dow has far more collaborations with universities than it does with federal labs." A factor, he says, is the longer association industry has had with academia compared with federal labs.

The level of familiarity and thus the ease of cooperation varies even among the different government organizations, notes Tom Patterson, external R&D manager for Dow's Texas and Louisiana sites. For example, he believes that the negotiation process is slower with DOE than it is with NIST, which has more years of experience working with industry.

According to NIST, its CRADAs take only about a month to implement, compared with several months or much more for other federal agencies. With industry and government having moved along the learning curve, government and industry technology transfer managers now believe that the negotiation process can be reduced to a few months.

"[A few years ago], the time frame was very long, and a DOE CRADA was very one-sided—very much for the government and not for industry," says Patterson. "Since then, there have been a number of different versions [of the agreement contract], and with each version there is improvement. The paperwork is becoming more palatable to industry, but it still is a very long document." As much as six months can pass while DOE, lab, and company attorneys agree on appropriate wording, he adds. But if the parties remain the same, negotiating a second CRADA can be done much faster.

Faith Silver, a DuPont patent associate focusing on the company's CRADA relationships, says that DOE has tried to use the experience it has gained in negotiating with companies, as well as delegating more authority to lab sites. DOE has created a "modular CRADA," in which alternative language can be substituted easily to suit given situations. "I think DOE has [tried] to understand industry's point of view in creating the modular CRADA," she says. "And DuPont has tried to set up contacts at the various labs . . . and a single voice within DuPont to speak for the needs of the company."

DuPont has 26 active CRADAs with different government orga-

New refrigerants developed through CRADAs are tested in industry facilities.

## Federal laws direct technology transfer

**Legislation directing technology transfer by the government is more than a decade old. The Bayh-Dole Technology Transfer Act of 1980 set the stage by giving the government the right to own patents and by allowing nongovernment organizations to obtain patents or licenses on inventions developed with federal funding. Also in 1980, the Stevenson-Wydler Technology Innovation Act mandated that a small percentage of national laboratory funding be used for technology transfer.**

Later, the Federal Transfer Technology Act of 1986 established the cooperative R&D agreement (CRADA) mechanism to promote the commercialization of federal technology from government-owned and -operated labs. By 1989, the National Competitiveness Technology Transfer Act firmly established technology transfer as a mission of all federal labs and facilities, including government labs operated by contractors. Continuing competitiveness initiatives, strategic plans, reorganization and redirection of lab roles, and other inducements by government departments and agencies have spurred technology transfer efforts by national labs.

Among the latest initiatives is Secretary of Energy Hazel R. O'Leary's April 1994 strategic plan (C&EN, April 25, page 34) directed at using Department of Energy's "tremendous scientific and technological assets ... to help U.S. industry compete in a global economy." O'Leary's plan complements an earlier one that promoted "partnerships for global competitiveness" between DOE labs and U.S. industry (C&EN, Aug. 9, 1993, page 15). DOE is among the most active, having set up 974 CRADAs since mid-1991.

More than 90% of DOE CRADAs are at several major national laboratories—Sandia (295), Oak Ridge and its associated Y-12 plant (182), Lawrence Livermore (134), Los Alamos (111), Argonne (72), Pacific Northwest (53), and Lawrence Berkeley (50). Leading industry participants with 10 or more DOE CRADAs include GM (40), American Textile Partnership (30), California Institute for Energy Efficiency & Sponsors (22), IBM (18), United Technologies (16), Amoco (14), General Electric (12), DuPont (12), AT&T (11), and Hewlett Packard (10). Dow Chemical has nine.

nizations. The topics include the use of new or alternative refrigerants, supercomputing capabilities and computer modeling for chemical processes, high-temperature superconductors, and environmental treatment technologies. The company has another 27 CRADAs at various stages of discussion, says Randy Guschl, DuPont's director of corporate technology transfer, any six of which could become active by the end of this year.

DuPont is part of a $1 million CRADA signed in January with Monsanto, General Electric, and EPA to develop bioremediation technology to clean up hazardous waste sites (C&EN, Jan. 31, page 9). Each organization had been conducting work separately, says Philip Brodsky, Monsanto's director of corporate research and environmental technology, but the CRADA seemed to be a very good fit of complementary technologies, skills, and perspectives. The group recently received grant approval to demonstrate the technology at a DOE site.

"When EPA offered us a forum to propose collaborative research, we took advantage of that," he adds. "So far it has worked really well; we've actually helped each other advance the technologies." In addition, the CRADA has been called a new paradigm for EPA, in which it can act as a technical partner in solving environmental problems rather than just policing them.

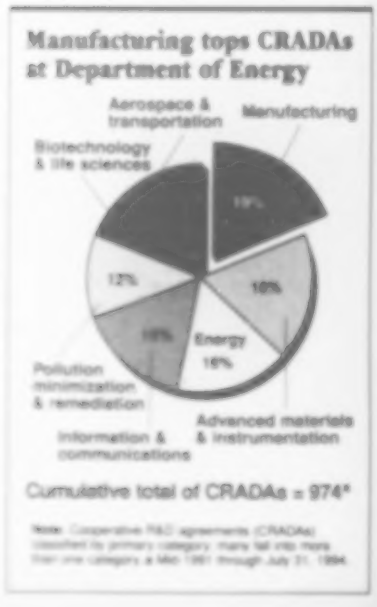
The collaborative work also is facilitated because the technology being developed is viewed as noncompetitive and intended primarily for internal use. "All of the participants have remediation problems that they would like to deal with better, faster, cheaper," says Brodsky. "And it's really in everybody's best interest to come up with improved technology ... and get these remediation problems behind us and get on with business.

"In that sense maybe the CRADA is a little unique. If we were trying to join forces on technology which would be perceived as competitive, I think there would be many more issues," he continues. Some technology managers believe that CRADAs with consortia are more easily negotiated and the terms are more liberal because they avoid issues of unfair access to federal research and competitive advantages.

Technology transfer managers say that CRADA language relating to proprietary information and patent rights has become much more reasonable and balanced. Some go so far as to say that a CRADA is much more like a typical agreement with another company and that the overall negotiation process has become no more difficult than it is with universities or within industry. "At least the starting position [in CRADA negotiation] is balanced," comments one manager. "I think that is all one can ask for."

"If you see a major [intellectual property] issue, you can choose to do a part of the research where it won't be a problem," says Guschl. Under a CRADA, the government retains the right to use anything developed for its own purposes. "We don't have a problem with [that], it's fundamental in all government work and should be there," says Guschl, and other managers agree. "But in order to recover the investment of time and monies in developing a technology, we need to be able to develop and deploy that technology without a lot of others having direct access to it. So [the ability to get an exclusive license or patent] has become very important in negotiations."

But managers see a CRADA clause addressing U.S. competitiveness as a remaining issue. Specifically, many agreements require that products based on intellectual property developed under a CRADA be "substantially manufactured" in the U.S. In addition, any processes or improvements must be made in the U.S. at least simultaneously with, if not prior to, being made outside the



*A Lawrence Livermore National Lab scientist tests the insulation provided by silica aerogels, one of many high-tech materials studied under CRADAs.*

U.S. while also not reducing the use of the technology in the U.S. DuPont chooses the technology for a CRADA carefully, says Silver, "We still have an interest in keeping DuPont a global business, and we feel that it is an economic concern for the United States to keep businesses such as DuPont healthy."

Defining the term "substantial" is left to the company, explains Patterson, and for an existing business, this can be done in terms of its current and projected operations. If the definition is accepted, it is incorporated in an addendum to the CRADA. But for new businesses, the manufacturing requirement can cause problems. "Frankly, some of the technology from the labs interests Dow for the longer term," Patterson says, "so we have accepted the clause without modification since market development and growth are not well-defined at this early stage.

At the same time, most industry technology transfer managers acknowledge the government's position and understand its desire to see transferred technology serve the interests of U.S. economic development.

A controversy relating to competitiveness has arisen with NIH CRADAs. NIH has been including language that gives it the right to specify prices for products developed under CRADAs. As a result, CRADAs with pharmaceutical and biotechnology companies have been hampered (C&EN, May 2, page 16). However, an NIH advisory panel recently has recommended that NIH drop the pricing policy.

Although technology transfer managers agree that the negotiation process has improved, they now say that industry faces a more serious problem. "Money is the biggest issue; everything else is secondary," says Patterson. "Industry first was frustrated by the paperwork taking too long, and now we're being frustrated by having the paperwork in order; having these huge labs, excellent facilities, and outstanding world-class researchers; having identified people we want to work with and who want to work with us; but unfortunately now [there isn't] the [federal] funding."

Opportunities simply to redirect funds seem slight, say managers, especially because the specific goals of a federal lab often do not overlap with those of a company. Adds Guschl: "A lot of the barriers have been worked out in the last few years, but we hear rumblings that CRADA funding might not continue as aggressively ... and we are concerned about that, as we'd like to see the CRADA relationships continue.

"DuPont sees the need—partly because of the cost savings, partly because of the leveraging, partly because you can get to an answer quicker—to go to external technology sources and work with people whether [in] universities or government labs. We can envision in three to five years having as much as 5 to 10% of our R&D budget being deployed outside the company."

Many companies look to get involved in cooperative agreements, rather than in direct licensing of federal technology. "It's far more valuable to get involved with either a federal lab, or a university, on the ground floor of a research program and collaborate on specific work of interest to both parties," says Tabor of Dow, "and then have the opportunity to license technology if patents evolve." This approach also usually affords a company a more favorable position in negotiating patent rights and options for exclusive licenses, especially if funding was involved.

"If a lab truly had a technology available that was ready to license and it met the company's needs, we might indeed look at that. But as much as the federal labs around the country do have existing patents that they are trying to license through their technology-transfer offices, frankly we at Dow spend very little time looking at that existing patented technology. Same thing goes for university technology," says Tabor. "A lot of effort [gets] expended for very little return." □

## Purified terephthalic acid capacity takes off

The market for purified terephthalic acid (PTA) is not a bad place for a chemical producer to be right now. Although the recession wreaked havoc on many chemical and plastic businesses, the PTA market seems to have emerged from the latest economic downturn largely unscathed. What's more, demand for PTA, which is a key raw material for production of polyester fibers and polyethylene terephthalate (PET) bottle resin and film, is expected to continue to grow roughly 8% per year at least until the end of the decade.

As a result, producers large and small have launched a bevy of expansion projects around the world. In the Asia-Pacific region, where most of the construction is concentrated, PTA capacity will rise by roughly 5 million metric tons between 1994 and 1998, representing a whopping 81% increase, according to Mary Belton Blackburn, director of polyester raw materials at Houston-based consultants Chemical Marketing Associates Inc. (CMAI). Major producers have been particularly aggressive, announcing expansion projects and conducting feasibility studies for more new plants even before they have completed construction of many others.

Producers say this latest capacity spurt is not due to any real unexpected jump in demand for PTA. Rather, capacity additions are needed to keep pace with demand, says Janice Florin, vice president for global business management for the chemical intermediates group at Chicago-based Amoco Chemical, which dominates the world market for PTA, with roughly 40% of worldwide capacity through wholly owned and joint-venture plants.

"It may seem that these expansions are happening all at once, but at Amoco at least, they are all part of a deliberate growth plan," says Florin. "Our expansion plans have been in the works for quite awhile, and a number of projects are just now coming to fruition. We have to be planning these expansions well in

advance based on projected growth rates and taking into account that PTA plants take two to three years to build."

London-based ICI, the world's second largest producer of PTA, agrees that the current onslaught of expansion activity is tied directly to "consistently strong growth in downstream polyester fiber and PET markets through the 1980s and now into the 1990s," according to a spokesman. But there's more to it than that. The current surge in activity has been sparked also by product shortages and high prices caused by underinvestment in new capacity between 1992 and 1994. Until recently, producers had been timid to provide funds to build new plants after having been burned by low prices and overcapacity in the 1989–91 period, says the ICI spokesman.

Despite the lessons learned in the past, ICI predicts that PTA producers will carry the current capacity boom too far, leading to another overcapacity problem by the late 1990s. "Some producers who are investing in sub-world-scale plants and old technology will find it very difficult to compete at this time," says the spokesman.

However, Amoco's Florin is hesitant to predict a future glut just yet. "It's too early to tell how supply will balance with demand in the late 1990s, because we don't know just how many of the announced expansion projects will actually bear fruit."

One limiting factor may be an impending shortage of *p*-xylene, the key feedstock for PTA production. Producers of *p*-xylene are not announcing expansion plans to keep pace with projected demand, especially in the Asia-Pacific region, notes CMAI's Blackburn, who will complete a study of world xylene and terephthalate markets through 2000 by the end of the year.

The "extremely healthy" state of the PTA market is a huge factor in gauging how supply and demand will balance out later in the decade, Florin says. Demand for polyester fiber is very strong in the Asia-Pacific region. And the PET container resin market has taken off over the past few years in North America, with current growth rates being pegged as high as 20% per year, she says.

Not surprisingly, North America may well be the center of the next round of PTA expansion announcements. In late June, Amoco announced plans to increase yearly PTA capacity by 115,000 metric tons at its Decatur, Ala., facility, with start-up scheduled for the second half of 1995. In addition, she says Amoco is "currently studying another North American expansion beyond the one at Decatur."

With its plants at Decatur and at Mt. Pleasant (Cooper River), S.C., Amoco is the only merchant producer of PTA in the U.S. However, ICI may disturb that position; the company is carrying out its own feasibility study for a U.S.-based PTA plant. The ICI spokesman could not give a date by which a decision will be made. In the U.S., ICI is a significant consumer of dimethyl terephthalate and will become a significant consumer of PTA when its new PET resin plant in Fayetteville, N.C., starts operating in the first quarter of 1996.

Meanwhile, ICI has announced expansions in Southeast Asia, the geographic region with the greatest demand for PTA. In early July, ICI confirmed that it had started engineering design work on a second PTA plant at its Kuan Yin site in Taiwan. The new 450,000-metric-ton-per-year plant is slated to operate in 1997. In addition, ICI plans to boost capacity at the existing two-year-old plant at Kuan Yin from 350,000 to 400,000 metric tons per year in 1995. "Continued growth in demand in Taiwan and the success of our existing purified terephthalic acid operation encouraged us to consider a further investment," says David Hewitt, ICI's international PTA business manager.

In addition, ICI plans to build a 400,000-metric-ton-per-year PTA plant at Port Qasim in Pakistan that will start operating in 1997. The investment will be made by ICI Pakistan, which is 61.5% owned by ICI; the remaining share is publicly traded in Pakistan. Deryk King, managing director of ICI's international polyester business, points out that PTA demand from the polyester fiber industry is now strong enough to justify building a plant in Pakistan, where ICI has been considering such an investment for some time. ICI expects that most of the plant output will be sold domestically, "but its leading cost economics will also enable the plant to compete aggressively in export markets."

Amoco is also extremely active in the Asia-Pacific region. The company's wholly owned facility in Kuantan, Malaysia, will add 500,000 metric tons per year of PTA capacity when commercial production begins in the second half of 1996. In addition, Amoco and the Japanese company Mitsui recently announced plans to build a jointly owned 350,000-metric-ton-per-year plant in Merak, West Java, Indonesia; construction has not yet begun but the plant is expected to begin operation in 1998, says Florin. Amoco's existing PTA joint ventures in Asia, China American Petrochemical Company Ltd. (CAPCO) and Samsung Petrochemical Company Ltd. (SPC), are also completing expansion projects due to start production in 1996, she says. CAPCO is building a 350,000-metric-ton unit in Taiwan; SPC's 250,000-metric-ton unit is in South Korea. In addition, Amoco has a project under way to build a 250,000-metric-ton-per-year PTA plant in Zhuhai, Guondong Province, China, says Florin.

Amoco is also keeping an eye on the European and South American PTA markets. In Europe, the company is evaluating capacity expansions, both in Geel, Belgium, where it now has a 250,000-metric-ton-per-year PTA unit, and in other locations.

In addition, this past March, Amoco do Brasil and Rhodia S.A., a subsidiary of France's Rhône-Poulenc, announced plans to evaluate the feasibility of modernizing and expanding their jointly owned PTA plant in Paulina, Brazil. Rhodiaco Industrias Quimica, a joint venture between the two companies, is considering boosting PTA capacity at its jointly owned facility from 110,000 to 230,000 metric tons per year. The feasibility study is expected to be completed sometime in October. Construction will begin by year's end and will be completed by late 1996.

*Susan Ainsworth*

**Expansions will boost global PTA capacity 62% by 1998**

| Thousands of metric tons | 1994 | 1998 | % change 1994–98 |
|---|---|---|---|
| Asia-Pacific | 6,510 | 11,775 | 81 |
| North America | 2,783 | 3,194 | 15 |
| Western Europe | 1,220 | 1,370 | 12% |
| Eastern Europe | 0 | 330 | — |
| South America | 190 | 310 | 63 |
| Africa & Middle East | 70 | 420 | 500 |
| TOTAL CAPACITY | 10,773 | 17,399 | 62% |

Source: Chemical Marketing Associates Inc.

# Senate Approves Slight Increase To $80.9 Billion For 1995 Federal R&D

■ ***NIST appropriation would increase by half; gains by NSF, Defense, and NIH would be more modest in this budget***

**Janice R. Long,** C&EN Washington

The Senate has completed action on its versions of the fiscal 1995 appropriations bills. Overall, it has been more generous than the House in providing money for research funding agencies, allowing for a 1% rise over current funding levels to $80.9 billion. That's 2% more than the Administration had requested and 4% more than the House allowed (C&EN, July 11, page 25). Differences between the two branches' bills are now being settled by conference committees made up of members of the House and Senate Appropriations Committees.

Although it was able to provide an increase for this year, the Senate Appropriations Committee is concerned about the future of the federal R&D effort in the face of tight fiscal constraints. The National Science Foundation is a major beneficiary of this year's relative largesse and won praise from the Appropriations Committee for its efforts to address national needs.

NSF's total budget is slated to rise 14% to $3.5 billion, with funding for the research and related activities account also up 14% to $2.3 billion. Support for education and human resource programs would rise 186% to $606 million. The House provided for an overall increase of 12%, with research and related activities up 11%, and education and human resources up just 3%.

But the top gainer in the NSF budget itself was the academic research infrastructure account, which the Senate wants to increase by 186% to $300 million. However, not all of that money is intended for NSF, and most of it may never get spent. The Senate reserved $190 million for a new interagency academic research facilities and instrumentation modernization program. The funds would be available between Sept. 1, 1995, and Aug. 31, 1996. However, their release is contingent upon two criteria. First, the Administration has to submit to Congress on or before Sept. 1, 1995, a five-year strategy for the new initiative, which is to be run by NSF but cover all federal science mission agencies. Second, it has to request more funds for the initiative in fiscal 1996. If these two conditions are not met, the Senate Appropriations Committee says it likely will just rescind the money.

The Department of Defense also did quite well. The Senate provided a 5% increase to $37.8 billion for DOD's R&D programs, compared with the 2% cut to $35.1 billion slated for the same programs by the House. The House had directed DOD to cut $900 million in university research support out of its total fiscal 1995 R&D budget. The Senate, fearing that such a one-year decrease might disrupt legitimate defense-related research and cause undue hardship for the university community, decided to limit the cut to $82 million.

The Department of Commerce's National Institute of Standards & Technology fared just about equally well in both branches of Congress, with the Senate providing a 69% increase to $879 million, compared with the House's 62% increase to $842 million. Under NIST's Senate appropriations bill, funding for intramural chemical science and technology programs would rise 70% to $37.8 million, while funding for the Advanced Technology Program (ATP)—a shared-risk, industry-led program of joint R&D ventures designed to enhance U.S. competitiveness—would rise 121% to $441 million. That amount should enable NIST to provide an additional 200 ATP awards.

The National Institutes of Health is slated for a 4% rise to $11.3 billion under both the Senate and House appropriations bills. And both branches provided for a 3% increase to $902 million for the National Institute of General Medical Sciences, which provides the majority of NIH's chemical research funds.

Funding for the Department of Energy's energy R&D programs would fall 10% to $5.1 billion under its Senate appropriations bills, with funding for chemical sciences down 4% to $162 million and that for materials sciences down 1% to $274 million. The House, while cutting the overall energy R&D budget by the same percentage as the Senate, cut funding for chemical sciences 2% and froze funding for materials sciences. Funding for DOE's weapons R&D programs would fall 32% under both bills to $777 million.

Both the Senate and the House also allowed a 2% increase to $5.9 billion for the National Aeronautics & Space Administration's science, aeronautics, and technology programs. The Senate froze funding for the Department of Agriculture's research programs at $1.4 billion, while the House cut funding 4%.

Quite often, some of the most interesting information to come out in the annual appropriations process isn't contained in any of the 13 major funding bills, but rather it is in the written reports that accompany the bills to the House and Senate floors. Federal agencies tend to take that language very seriously indeed.

This year's Senate report on NSF's bill stands in sharp contrast to the one issued by the Appropriations Committee last year, which essentially told NSF that it had to start addressing, in a concrete way, the country's social and economic needs or see its money go to agencies that would do so. This year, there were nothing but kind words for NSF in the report that accompanied the VA, HUD, & Independent Agencies Appropriation bill.

The report praises the NSF director and the National Science Board for engaging

## NIST, NSF get big boost in Senate-approved '95 R&D budget

| $ Millions | 1994 | 1995 Administration request | 1995 Senate appropriation | % difference, appropriation-request | % change 1994–95 |
|---|---|---|---|---|---|
| **Defense** | **$35,888** | **$35,962** | **$37,763** | **5%** | **5%** |
| Development | 26,327 | 26,652 | 28,626 | 7 | 9 |
| Operational systems | 11,474 | 10,906 | 13,341 | 22 | 16 |
| Engineering & manufacturing | 7,441 | 8,916 | 8,850 | –1 | 19 |
| Advanced | 4,669 | 3,846 | 3,621 | –6 | –22 |
| Exploratory | 2,743 | 2,984 | 2,814 | –6 | 3 |
| Management & support | 3,218 | 3,079 | 2,959 | –4 | –8 |
| Ballistic Missile Defense Organization | 2,440 | 2,440 | 2,559 | 5 | 5 |
| Demonstration & validation | 2,698 | 2,566 | 2,497 | –3 | –7 |
| Basic research | 1,205 | 1,225 | 1,122 | –8 | –7 |
| **NASA** | **15,113** | **14,284** | **14,035** | **–2** | **–7** |
| Science, aeronautics & technology | 5,788 | 5,901 | 5,901 | 0 | 2 |
| Human space flight | 6,672 | 5,720 | 5,574 | –3 | –16 |
| Mission support | 2,653 | 2,663 | 2,560 | –4 | –4 |
| **Energy** | **12,742** | **12,168** | **11,748** | **–3** | **–8** |
| Environmental restoration & waste management | 5,899 | 5,961 | 5,858 | –2 | –1 |
| Energy R&D | 5,706 | 5,411 | 5,113 | –6 | –10 |
| General science & research | 1,615 | 1,110 | 974 | –12 | –40 |
| Superconducting Super Collider termination costs[a] | 640 | 180 | 0 | na | na |
| Supporting research & technical analyses | 976 | 956 | 949 | –1 | –3 |
| Materials sciences[a] | 277 | 274 | 274 | 0 | –1 |
| Chemical sciences[a] | 169 | 162 | 162 | 0 | –4 |
| Waste R&D | 687 | 703 | 703 | 0 | 2 |
| Conservation | 385 | 588 | 445 | –24 | 16 |
| Biological & environmental research | 416 | 435 | 445 | 2 | 7 |
| Fossil | 431 | 451 | 436 | –3 | 1 |
| Solar & renewables | 347 | 398 | 353 | –11 | 2 |
| Fusion | 348 | 373 | 363 | –3 | 4 |
| Nuclear | 341 | 248 | 308 | 24 | –10 |
| Environment, safety & health | 160 | 149 | 137 | –8 | –14 |
| Weapons R&D | 1,137 | 796 | 777 | –2 | –32 |
| **NIH** | **10,938** | **11,471** | **11,333** | **–1** | **4** |
| National Institutes | 10,001 | 10,433 | 10,001 | –4 | 0 |
| General Medical Sciences[a] | 876 | 908 | 902 | –1 | 3 |
| National Center for Research Resources | 332 | 351 | 358 | 2 | 8 |
| National Center for Human Genome Research | 127 | 152 | 152 | 0 | 20 |
| Other | 478 | 535 | 496 | –7 | 4 |
| **NSF** | **3,018** | **3,199** | **3,454** | **8** | **14** |
| Research & related activities | 1,993 | 2,348 | 2,265 | –4 | 14 |
| Education & human resources | 570 | 586 | 606 | 3 | 6 |
| Major research equipment | —[b] | 70 | 150 | 114 | na |
| Academic research infrastructure | 105 | 55 | 300 | 445 | 186 |
| Other | 350 | 140 | 133 | –5 | –62 |
| **USDA** | **1,416** | **1,347** | **1,416** | **5** | **0** |
| Agricultural Research Service | 728 | 725 | 738 | 2 | 1 |
| Cooperative State Research Service | 495 | 419 | 480 | 15 | –3 |
| Forest research | 193 | 203 | 198 | –2 | 3 |
| **Commerce** | **747** | **1,166** | **1,121** | **–4** | **50** |
| National Institute of Standards & Technology | 520 | 935 | 879 | –6 | 69 |
| Oceanic & atmospheric research | 227 | 231 | 242 | 5 | 7 |
| **TOTAL** | **$79,962** | **$79,597** | **$80,870** | **2%** | **1%** |

a Funds included in preceding total. b Data not available. na = Not applicable.
**Source:** Senate Appropriations Committee reports

"the scientific and engineering communities in a strategic planning process that recognizes the new realities and opportunities of the post-Cold War world order." It noted that NSF is improving its working relationships with other government agencies and industry and is putting in place formal mechanisms to reassess program priorities for the long term, set appropriate performance milestones and evaluation methods, and ensure accountability in the management and implementation of strategic research and education initiatives.

About the only things the committee was concerned about, as noted in the report, are that NSF draws only 5% of its expert reviewers from industry and that only 15% of its reviewers are new each year. The committee directed NSF to achieve an average of at least 10% industry reviewers within the next year and use a "significantly" higher percentage of new reviewers.

The Senate Appropriations Committee's overall assessment of the state of the federal R&D effort is not optimistic. In the NIH report, it notes that federal research agencies are being "confronted with constrained resources resulting from the virtual freeze in discretionary outlays." And it warns: "This freeze will make decisions over how to best allocate funding for R&D in the future all the more difficult as research opportunities collide with other governmental responsibilities required for preserving [and] protecting the health, safety, and economic security of our citizens."

These realities, the committee says, have compelled it to consider the composition of the overall federal R&D budget. It is particularly concerned whether that research budget is designed to meet new national security, military, economic, and health issues that confront the nation. To find out whether these concerns can be addressed at the present funding levels, the committee provided NIH with $1 million to commission a study from the National Academies of Sciences and Engineering and the Institute of Medicine. The study is to consider the criteria that should be used in judging the appropriate allocation of funds to research and development activities, the appropriate balance among the different types of institutions that conduct such research, and the means of ensuring continued objectivity in the allocation process. The study is due Dec. 31, 1995. □

# EPA tries to pare number of toxics release forms

The Environmental Protection Agency would like to cut down on the number of Toxics Release Inventory (TRI) forms it has to process each year. So the agency has proposed exempting facilities that transfer or release less than 100 lb per year of a listed chemical from TRI reporting requirements. EPA estimates this exemption would save industry $26 million in costs and result in 20,500 fewer TRI reports filed with EPA.

The proposed regulation comes in response to petitions filed with EPA in 1991 and 1992 by the Small Business Administration (SBA) and the American Feed Industry Association (AFIA). The two groups maintain that many very small facilities incur too much expense trying to comply with the current regulation. "The TRI database is not meaningfully improved by countless entries of zero or de minimis release figures," states the SBA petition.

AFIA asked that its entire industry be exempted from the reporting requirement because its companies release such small amounts of chemicals into the environment that the information does not contribute anything significant to the TRI database. In fact, Brian L. Bursiek, director of feed production at AFIA, claims that a 100-lb exemption would eliminate 50 to 60% of the TRI forms that now have to be filed. Most of the substances released by AFIA facilities result from the addition of nutrients such as manganese, zinc, and copper sulfate to processed feed.

In view of this, EPA has looked at the TRI data to see if some of the information collected may be of lesser value than some of the new reports expected to result from EPA's current efforts to expand TRI. Because of the large number of forms it found reporting zero-release amounts, the agency decided to see if a low-release exemption would work.

EPA says it received 10,200 reports on 1991 TRI release forms that recorded zero releases or transfers. "EPA believes that the space that such reports consume in the database and the effort necessary to submit the reports would be better applied to those additional reports that contain positive values for releases and transfers of toxic chemicals," the agency states in the proposed regulation.

Although EPA has removed some chemicals from the TRI reporting list, the proposed exemption would be the first major regulation issued by EPA cutting back release reporting. TRI was created in the 1986 Superfund reauthorization bill and has subsequently become one of the agency's primary information sources. The law requires any manufacturing facility that handles more than 25,000 lb per year of a listed chemical to report to EPA any releases of the chemical into the environment, or any transfers or treatments of those chemicals. The inventory list contains more than 300 chemicals and 20 chemical categories. For 1992, the latest year's data, EPA received more than 81,000 reports from companies.

And the agency is in the process of a major expansion of the scope of TRI. In January, EPA proposed adding 313 substances to the list of reportable chemicals and requiring facilities outside the manufacturing sector to report releases. Those changes are expected to increase the number of reports by about 28,000 annually, EPA estimates. An exemption for very minor releases could probably significantly lower that number.

However, companies that release less than 100 lb of a listed chemical will not get away from EPA paperwork entirely. To qualify for the exemption, a company would have to file an annual certification statement in lieu of the full form inventory report. A company would have to include much of the same data included on the TRI form, but indicate that the substance released falls into a range of 0 to 99 lb and qualifies for the exemption.

Bursiek of AFIA thinks such annual reporting is unnecessary. "We contend that once you have claimed an exemption, you should not have to do that every year," he says. Filing the similar paperwork each year seems to negate the advantage of the exemption, he believes.

But the agency says that annual certification is in keeping with the statutory requirement of the law and will provide data on the manufacture and processing of the listed chemicals. It will also "foster continued attention to chemical management practices and provide a location tool vital to any compliance program," the proposed regulation states.

EPA estimates if the exemption becomes final at 100 lb, about 15 chemicals will no longer be reported at all on the inventory. These chemicals were only reported on 26 forms in 1991. The greatest volume among them was for 2,4-diaminoanisole, which one company reported releasing a total of 85 lb that year. The total amount released for all 15 chemicals was less than 320 lb.

While some industries, such as AFIA, would gain some advantage from this kind of exemption, the chemical industry sees little that will help it. Nancy Lawson of the Chemical Industry Council of New Jersey says that an exemption level of 100 lb is just too little. "EPA is kind of throwing us a bone," she says. A larger volume exemption, say of 500 lb, would be more appropriate for chemical firms, she adds.

Cheryl O. Morton, manager of government relations at the Washington, D.C.-based Synthetic Organic Chemical Manufacturers Association, which represents many smaller chemical companies, says that the industry is at best lukewarm to the EPA proposal. The original SBA petition was for a 5,000-lb exemption, Morton says, and that is what would provide the relief from TRI reporting that the industry needs. She agrees with Lawson that few chemical facilities would be expected to benefit from a 100-lb reporting exemption.

Environmental activists are wary of EPA efforts that might result in less information being made available to the public about hazardous chemicals. A spokesperson for the Environmental Defense Fund, for example, says a threshold exemption would be a step backwards if it did not include all material sent for recycling and not just material released. Even then, a threshold of 100 lb might still be unacceptably high.

*David Hanson*

## Exempting small volumes cuts down on TRI reports

| Threshold level (lb) | No. of reports affected (thousands) | Volume of waste unreported (lb) | % of total waste reported |
|---|---|---|---|
| 0 | 10.2 | 0 | 0.00% |
| 10 | 16.2 | 35,000 | 0.00 |
| 100 | 20.5 | 200,000 | 0.01 |
| 250 | 26.2 | 1,400,000 | 0.03 |
| 500 | 33.0 | 4,000,000 | 0.1 |
| 1,000 | 38.9 | 8,400,000 | 0.2 |
| 5,000 | 50.1 | 36,200,000 | 0.8 |

**Note:** Data are from 1991 Toxics Release Inventory reports of releases of specified toxic chemicals and of transfers of them for the purpose of treatment and disposal. **Source:** Environmental Protection Agency

# Second And Third Groups Of ACS-PRF Grants Approved

Acting on recommendations from the February and May meetings of the Petroleum Research Fund Advisory Board, the ACS Board of Directors approved 251 new or continuing ACS-PRF grants-in-aid with a total value of $7,814,252. The recommended grants were selected from 833 proposals and are the last projects to be funded in 1994. ACS-PRF grants are funded by income from a trust established in 1944 by seven major oil companies. No ACS member dues income is used for PRF grants or administrative expenses.

Continuing low interest rates have reduced income available for new PRF grant commitments. New PRF grants declined from $14.4 million in 1992 and $12.9 million in 1993 to $12.3 million in 1994. A further decrease in commitments in 1995 is probable. The 1994 success rates are 23% for Type AC grants, 44% for Type B grants, and 36% for Type G "Starter" grants.

In order to hold the projected 1995 success rate for Type AC proposals above 20%, the supplements for Summer Research Fellowships for faculty from undergraduate departments will be suspended in 1995 and 1996. Further, applicants for a Type AC grant which is not funded may not have another AC proposal considered until 12 months later.

The "38th Annual Report on Research Under Sponsorship of The Petroleum Research Fund" is now available. Individuals who wish a complimentary copy, or information and application forms for ACS-PRF grants to commence in 1995, should write the Petroleum Research Fund, American Chemical Society, 1155—16th Street, N.W., Washington, D. C. 20036; phone (202) 872-4481.

## ACS-PRF Grants for Fundamental Research in the Petroleum Field (Type AC)

**John B. Anderson,** Rice U. Architecture of Late Pleistocene to Holocene Incised Valley-Fills on the Texas Shelf. $50,000

**James K. Bashkin,** Washington U. Functional Mimics of Ribozymes: Catalytic DNA. $50,000

**Peter F. Bernath,** U of Waterloo. Laser and Fourier-Transform Spectroscopy of Free Radicals. $50,000

**Kit H. Bowen Jr.,** Johns Hopkins U. Magic Clusters: Their Formation and Characterization in Beams and the Bulk. $50,000

**Udo H. Brinker,** State U of New York, Binghamton. Carbenes in Constrained Systems. $50,000

**Philip R. Brooks,** Rice U. How Does Molecular Orientation Affect Electron Transfer? $50,000

**Kenneth L. Brown,** Mississippi State U. Diastereomerism in Organocobalt Corrinoids. $50,000

**Douglas W. Burbank,** U of Southern California. Style and Rate of Detachment Folding and Impacts on Coeval Depositional Systems. $50,000

**Theodore J. Burkey,** U of Memphis. Hydrogen Activation by Transition-Metal Complexes. $50,000

**William D. Carlson,** U of Texas, Austin. Compositional Dependence of Apatite Fission-Track Annealing: An Experimental Approach. $50,000

**Barry K. Carpenter,** Cornell U. Elucidation of the Relationship Between Biradicals and Zwitterions in Organic Thermal Reactions. $50,000

**Arup K. Chakraborty,** U of California, Berkeley. Structure of the Interface Between Metals and Random Copolymers: Taking Steps Toward the Molecular Design of Adhesives. $50,000

**Daniel L. Comins,** North Carolina State U. Photocycloadditions of Dihydropyridones. $50,000

**Philip Coppens,** State U of New York, Buffalo. Diffraction Studies of Excited State Structure. $50,000

**James A. Cowan,** Ohio State U. Mechanistic Studies of Metallonuclease Enzymes. $50,000

**James V. Crivello,** Rensselaer Polytechnic Inst. Synthesis and Polymerization of Novel Ketene Acetal Monomers. $50,000

**M. David Curtis,** U of Michigan. Self-Assembling Conjugated Polymers. $50,000

**Robert J. Davis,** U of Virginia. Selective Oxidation of Hydrocarbons Over Titania-Silica Mixed Oxide Catalysts. $50,000

**John M. Dealy,** McGill U. Dynamic Wall Slip of Molten Polymers. $50,000

**David Deming,** U of Oklahoma. Overpressures, Temperature, and Hydrocarbon Generation in the Anadarko Basin. $50,000

**Michael F. Doherty,** U of Massachusetts. Design of Melt Crystallization Processes by Equation-Based Methods. $50,000

**James H. Edgar,** Kansas State U. Chemical Vapor Deposition of Diamond-Cubic Boron Nitride Alloys. $50,000

**Mark D. Ediger,** U of Wisconsin, Madison. Translational Diffusion of Probes in Polymers Near $T_g$. $50,000

**R. Lawrence Edwards,** U of Minnesota, Minneapolis. Mass Spectrometric $^{231}Pa/^{235}U$ Dating of Carbonates: Testing High Resolution Records of Quaternary Climate Change. $50,000

**Arthur B. Ellis,** U of Wisconsin, Madison. Chemical Sensors Based on the Photoluminescence of Metal-Complex-Coated Semiconductors. $50,000

**John L. Falconer,** U of Colorado. Catalytic Oxidation Mechanisms of Volatile Organic Compounds. $50,000

**Gerald W. Feigenson,** Cornell U. Monte Carlo Simulation of Nonideal Mixing in Model Membranes. $50,000

**Robert W. Field,** Massachusetts Inst. of Technology. Fundamental Mechanisms of Energy Exchange Between an Electron and a Molecular Cation. $50,000

**Randy S. Fishman,** North Dakota State U. Simulations of Void Formation in Organic Coatings and Other Composite Media. $50,000

**Eric L. Garfunkel,** Rutgers, State U of New Jersey. Initial Oxidation of Nickel and Silicon: From a Phenomenological Description to an Atomic-Scale Understanding. $50,000

**Robert E. Garrison,** U of California, Santa Cruz. Sequence Stratigraphic Modeling and Recognition of Sea-Level Changes in a Proximal Monterey Setting: Cuyama Basin of California. $49,961

**George R. Gavalas,** California Inst. of Technology. Membrane Preparation via Supported Carbon Layers. $50,000

**William E. Geiger Jr.,** U of Vermont. Redox Properties of Unusual Polynuclear Complexes. $49,940

**Gregory I. Gellene,** Texas Tech U. Nuclear Symmetry Restrictions in Chemical Reactions. $50,000

**Edwin S. Gould,** Kent State U. Hypovalent Metal Centers from Intramolecular Hydride Transfers. $25,000

**Martin Gruebele,** U of Illinois, Urbana-Champaign. Rapid Protein Folding Dynamics. $49,933

**Carol K. Hall,** North Carolina State U. Theories for Fluids Containing Chain-Like Molecules. $50,000

**Gary L. Haller,** Yale U. A Comparison of Amorphous and Mesoporous Molecular Sieve Silica-Aluminas. $50,000

**William W. Hay,** U of Colorado. Role of Large Amplitude Sea-Level Changes on the Late Neogene-Quaternary Increase in Sediment Delivery to the Deep Sea. $50,000

**Harold C. Helgeson,** U of California, Berkeley. Thermodynamic Constraints on the Chemical Evolution of Kerogen in Sedimentary Basins. $50,000

**Victor E. Henrich,** Yale U. Effect of Substrate Electronic Structure on the Chemisorption Properties of Cr-Doped $V_2O_3$. $50,000

**James W. Herndon,** U of Maryland, College Park. Development of New Annelation Reactions Using Z-Vinylacetylenes and Fischer-Carbene Complexes. $50,000

**Davide A. Hill,** U of Notre Dame. Relaxation of Monolayers of Dielectrically Responsive Polymers Tethered to Solid Surfaces. $50,000

**Michael F. Hochella Jr.,** Virginia Polytechnic Inst. & State U. Fundamental Processes at Mineral Surfaces: A Study Using Ambient and UHV-Based Scanning Probe Microscopies and Spectroscopies. $50,000

**George M. Homsy,** Stanford U. Flow, Transport, and Instabilities in Strongly Heterogeneous Porous Media. $40,000

**Martin F. Jarrold,** Northwestern U. Structural Dynamics of Pure and Doped Carbon Cluster Ions. $50,000

**Graham B. Jones,** Clemson U. Catalytic Asymmetric Induction Based on J Stacking Interactions. $50,000

**Stephen E. Kesler,** U of Michigan. Geochemistry and Significance of Methane in Mississippi Valley-Type Deposits. $50,000

**Saad A. Khan,** North Carolina State U. Rheology of UV Cross-Linked Polymers. $50,000

**David A. Kofke,** State U of New York, at Buffalo. Some New Ideas for the Treatment of Conformal Solutions. $5[illegible]00

**Paul J. Kropp,** U of North Carolina, Chapel Hill. Surface-Mediated Reactions. $50,000

**Stephen G. Kukolich,** U of Arizona. Microwave Measurements of the Structures of Transition-Metal Complexes. $50,000

**Richard C. Larock,** Iowa State U. Palladium-Catalyzed Annulation. $50,000

**Mario Leclerc,** U of Montreal. Synthesis and Characterization of Novel Electroactive and Photoactive Polyesters. $50,000

**Doreen G. Leopold,** U of Minnesota, Minneapolis. Studies of Transition-Metal-CO Bonding by Negative Ion Photoelectron Spectroscopy. $50,000

**Frederick D. Lewis,** Northwestern U. Photoswitchable Hydrogen Bonds. $50,000

**Mark A. Lipton,** Purdue U. Enantioselective Synthesis of Monosaccharides and Their Derivatives. $50,000

**Carl R.F. Lund,** State U of New York, Buffalo. Microkinetics of Water-Gas Shift Over Pd, Pt, and Rh. $50,000

**Przemyslaw B. Maslak,** Pennsylvania State U. Spiroconjugated Charge-Transfer Dyes. $50,000

**James R. Maxwell,** U of Bristol. 1-H-Pyrrole-2,5-Diones as Indicators of Redox Conditions in Ancient Water Bodies. $43,380

**Anne M. Mayes,** Massachusetts Inst. of Technology. Phase Diagram of Compressible Block Copolymer Melts. $25,000

**Andreas Mayr,** State U of New York, Stony Brook. Coordination Chemistry of Multiply Unsaturated Organic Ligands. $50,000

**David A. McConnell,** U of Akron. Study of Outcrop-Scale Structures in the Valley and Ridge Province, Appalachian Orogen: Implications for Fault-Fold Interactions. $18,950

**Michael J. McGlinchey,** McMaster U. Organometallic Cations and Anions. $50,000

**Peter S. Mozley,** Andrew R. Campbell, New Mexico Inst. of Mining and Technology. Petrographic and Geochemical Correlation of Carbonate-Cemented Horizons in Siliciclastic Rocks. $50,000

**Sohail Murad,** U of Illinois, Chicago. Computer Simulation Studies of Osmosis and Reverse Osmosis in Solutions. $50,000

**E. Bruce Nauman,** Rensselaer Polytechnic Inst. Self-Assembled Structures Resulting from Multicomponent Spinodal Decomposition. $50,000

**John S. Oldow,** Rice U. Low-Angle Displacement Transfer System in the Walker Lane Strike-Slip Belt, West-Central Nevada. $50,000

**Athanasios Z. Panagiotopoulos,** Cornell U. Monte Carlo Simulations of Phase Coexistence for Lattice Polymeric Models. $50,000

**Robert L. Powell,** U of California, Davis. Fluid Mechanics and Rheology of Suspensions of Bimodally Distributed Spherical Particles. $50,000

**Philip P. Power,** U of California, Davis. Synthesis and Structure of Magnesium Imide Cage Compounds and Their Applications as Synthetic Reagents. $50,000

**Daniel E. Resasco,** U of Oklahoma. Modification of the Role of Hydrogen in Alkane Dehydrogenation Catalysts by the Addition of Metal Promoters. $50,000

**J. Donald Rimstidt,** Virginia Polytechnic Inst. & State U. Clay Mineral Precursors Formed During Silicate Mineral Weathering. $50,000

**Mark O. Robbins,** Johns Hopkins U. Dissipative Mechanisms in Friction and Adhesion. $50,000

**Gregory H. Robinson,** Clemson U. Host-Guest Complexes as Templates for the Molecular Assembly of Novel Alanes Containing Al-Al Bonds. $50,000

**Matthew J. Rosseinsky,** U of Oxford. Synthesis of New Transition Metal Oxides. $50,000

**James P. Runt,** Pennsylvania State U. Interphases in Semi-Crystalline Polymer Blends. $50,000

**Douglas M. Ruthven,** U of New Brunswick. Zeolitic Diffusion in a Binary Adsorbed Phase. $50,000

**Cyrus R. Safinya,** U of California, Santa Barbara. Biomolecular Membranes Based on Lipids, Membrane-Associated Proteins, and Surfactant Polymers. $50,000

**Michael Savarese,** Indiana U. Paleobiological and Paleoenvironmental Context of Coralomorph-Bearing Lower Cambrian Reefs, South Australia: Implications for Paleozoic Reef Ecology. $49,981

**Cynthia K. Schauer,** U of North Carolina, Chapel Hill. Multielectron Redox Reactions of Transition-Metal Clusters: Origins and Chemical Implications. $50,000

**Juergen Schieber,** U of Texas, Arlington. Exploring the Origin of Large-Scale Erosion Surfaces in the Chattanooga Shale: Testament of Mud-Bank Migration? $50,000

**Gary J. Schrobilgen,** McMaster U. New Fluorides and Oxofluorides of Xenon(VIII). $50,000

**Gustavo E. Scuseria,** Rice U. Theoretical Studies of Fullerene Annealing and Fragmentation. $50,000

**Scott McN. Sieburth,** State U of New York, Stony Brook. Intramolecular Toolbox: Multipurpose Organosilanes. $50,000

**Jay S. Siegel,** U of California, San Diego. Investigation of Transition-Metal Tripods and Trinuclear Metal Clusters with Arenes: Theoretical and Experimental Models for Metal Catalysis. $50,000

**Bernd R.T. Simoneit,** Oregon State U. Characterization of Organometallic Complexes in Hydrothermal Petroleum. $50,000

**Jennifer L. Sinclair,** Carnegie Mellon U. Quantitative Prediction of Heat Transfer Rates in High Velocity Fluidization. $50,000

**James L. Skinner,** U of Wisconsin, Madison. Spectral Diffusion of Individual Molecules in Solids. $50,000

**Mark A. Smith,** U of Arizona. Temperature Dependent Free-Radical Kinetics Between 20 and 300 K. $50,000

**Stuart W. Staley,** Carnegie Mellon U. Effect of Molecular and Crystal Structure on Dynamic Processes in the Organic Solid State. $50,000

**Howard A. Stone,** Harvard U. Dynamics of Deformable Drops and Bubbles in Suspensions. $50,000

**Donald C. Sundberg,** U of New Hampshire. Polymer End Groups at Aqueous and Organic Interfaces: Influence on Latex Particle Morphology. $50,000

**Daniel R. Talham,** U of Florida. New Conducting and Superconducting Cation Radical Salts Based on High-Oxidation State Organic Donors. $50,000

**Boon K. Teo,** U of Illinois, Chicago. Single-Crystal X-Ray Diffraction and EXAFS Studies of Biand Trimetallic Clusters in Zeolite Cages. $50,000

**Frantisek Turecek,** U of Washington. Hydrochlorofluorocarbon Radicals. $50,000

**Veronica Vaida,** U of Colorado. Photoreactivity of Complexes via Time Resolved UV Fourier-Transform Spectroscopy. $50,000

**Philippe Van Cappelen,** Georgia Inst. of Technology. Controls on the Degradation and Preservation of Organic Carbon, Nitrogen, and Phosphorus in Marine Sediments. $50,000

**John G. Verkade,** Iowa State U. Atranes as Probes for Novel Chemistry and Structures. $50,000

**Paul Weimer,** U of Colorado. An Integrated Four-Dimensional Structural Analysis of Allochthonous Salt Sheets, Northern Gulf of Mexico. $38,957

**W. Henry Weinberg,** U of California, Santa Barbara. Bridging the Pressure Gap in Heterogeneous Catalysis: Use of Atomic Beams in Catalytic Hydrogenation Reactions. $50,000

**James C. Weisshaar,** U of Wisconsin, Madison. Gas-Phase Reactions of Neutral Transition-Metal Atoms with Alkanes and Alkenes. $50,000

**Mark E. Welker,** Wake Forest U. Synthesis and Reaction Chemistry of Unusual Transition-Metal $\eta^1$-1,3-dienyl, $\eta^1$-1,2-dienyl, and $\eta^3$-cyclobutenone Complexes. $50,000

**William Weltner Jr.,** U of Florida. Magnetic–Optical Studies of Small Clusters. $50,000

**Kenton H. Whitmire,** Rice U. Bismuth Oxo Cluster Compounds and Oxidation Catalysis. $50,000

**John M. Wiest,** Purdue U. Inception of Homogeneous Failure in Amorphous Solids: A Molecular Dynamics Study. $50,000

**Robert M. Williams,** Colorado State U. Synthesis and Biosynthesis of the Brevianamides/Paraherquamides. $50,000

**L. Keith Woo,** Iowa State U. New Group 14, 15, and 16 Transfer Reactions: Scope, Kinetics, and Mechanisms. $50,000

**Sidney Yip,** Massachusetts Inst. of Technology. Instabilities of Solids Under Stress. $50,000

**Tadeusz W. Zerda,** Texas Christian U. Diffusion in Small Pores and Gradient Index Sol-Gel Glass. $50,000

**John Z. H. Zhang,** New York U. Time-Dependent Approach to Diatom-Diatom Reactions. $50,000

## ACS-PRF Grants for Fundamental Research in the Petroleum Field (Type B)

**Alaa S. Abd-El-Aziz,** U of Winnipeg. Controlled Design of Oligomeric and Polymeric Arene Complexes. $25,000

**Edward R. Biehl,** Southern Methodist U. Preparation of Functionalized Polycyclic Arenes Using Arynic Methodology. $25,000

**Walter J. Bowyer,** Hobart & William Smith C. Rates and Mechanism of Grignard Reagent Formation by in situ Photomicrography of Magnesium Surfaces. $25,000

**Thomas M. Christensen,** U of Colorado, Colorado Springs. Exploring Interfaces: Three-Dimensional, Non-Destructive Characterization of Multilayer Film Systems. $25,000

**Susan T. Collins,** California State U, Northridge. Matrix-Isolation Studies of Excited-State Proton-Transfer Systems. $25,000

**Roger L. DeKock,** Calvin C. Theoretical Challenges in Transition-Metal Clusters That Include Main-Group Atoms. $25,000

**Thomas C. DeVore,** James Madison U. Rapid Scan FTIR Investigation of Metal Complex/Small-Molecule High-Temperature Chemical Reactions. $25,000

**Gregory W. Ebert,** State U of New York, Buffalo. Direct Formation of Halovinylcopper Reagents and the Carboxylation of Functionalized Arylcopper Compounds. $25,000

**Luther E. Erickson,** Grinnell C. Structural, Equilibrium, and Kinetic Studies of Platinum Complexes. $25,000

**Karen I. Goldberg,** Illinois State U. Reactivity Trends in Reductive Elimination Reactions. $25,000

**John T. Gupton,** U of Central Florida. Use of Vinylogous Iminium Salt Derivatives for the Regiocontrolled Synthesis of Trisubstituted Pyrroles: A Pyrrole Based Approach to Rigidin. $25,000

**Michael A. Kahlow,** U of Wisconsin, River Falls. Chemistry of Chlorin d Substituted Myoglobin. $25,000

**Frederick W. King,** U of Wisconsin, Eau Claire. Investigation of the Rydberg States of the Lithium Atom. $25,000

**Timothy D. Lash,** Illinois State U. Synthesis and Characterization of Novel Conjugated Macrocycles Related to the Oxophlorins. $25,000

**Joon C. Lee,** U of Southern Mississippi. Binary Liquids in Porous Media. $25,000

**John A. Maguire,** Southern Methodist U. Structural and Spectral Properties of Main Group J Complexes. $25,000

**Harmon D. Maher Jr.,** U of Nebraska, Omaha. Kinematic Evolution of Tertiary Structures in a Dextral Transpressional Plate Setting, Western Barents Shelf, Spitsbergen, Norway. $19,700

**Nancy S. Mills,** Trinity U. Dications of Bifluorenylidene: Factors That Affect Reactivity and Reactions in Phenyl-Substituted Polycations. $25,000

**Ronald L. Musselman,** Franklin & Marshall C. Polarized Specular Reflectance of Binuclear Metalloprotein Models and Planar One-Dimensional Conductors and Precursors. $25,000

**Paul M. Myrow,** Colorado C. Cambrian Tidal Sand Waves: Geometry, Sediment Dynamics, and Reservoir Potential. $24,450

**Allan M. Nishimura,** Westmont C. Triplet-Triplet Energy Transfer of Adsorbed Organic Species. $25,000

**Craig A. Ogle,** U of North Carolina, Charlotte. Chiral Resolution of Racemic Alkyllithium Reagents. $25,000

**John A. Olmsted III,** California State U, Fullerton. Studies of Energy and Charge Transfer in Transparent Sol-Gels. $25,000

**James H. Reynolds,** Western Carolina U. Magnetic Polarity Stratigraphy of Continental Strata in the Sierras Subandinas, Northwest Basin, Salta Province, Argentina. $25,000

**Rabindra N. Roy,** Drury C. Thermodynamic Study of Electrolyte Mixtures. $25,000

**Carl Salter,** Moravian C. Ab initio Investigation of the $N_3H_3$ Surface and Triaziridine-Polycyclic Ring Systems. $24,000

**Michael R. Sandy,** U of Dayton. Early Mesozoic Brachiopod Faunas from North America: Paleoenvironmental, Paleogeographic and Stratigraphic Significance, and Role in the Development of the Modern Brachiopod Fauna. $25,000

**Lauret E. Savoy,** Mount Holyoke C. Provenance Analysis of a Middle Paleozoic Marine Sequence, Southern Canadian Rocky Mountains: Link Between Tectonics and Sedimentation. $25,000

**Charles D. Schaeffer Jr.,** Elizabethtown C. Structure and Reactivity of Incipiently Hypervalent Compounds of Silicon and Tin. $25,000

**Karen A. Singmaster-Hernandez,** San Jose State U. Bis(trifluoromethyl)oxirene. $25,000

**Joanne A. Smieja,** Gonzaga U. Synthesis of Organoimido Metalloporphyrin Complexes: Possible Alkene Aziridination Reagents. $25,000

**James N. Spencer,** Claude H. Yoder, Franklin and Marshall C. A Comparative Study of Host-Guest Interactions in Aqueous and Nonaqueous Media. $25,000

**E. Timothy Wallin,** U of Nevada, Las Vegas. Test of a Parautochthonous Sonomia. $25,000

**Thomas C. Werner,** Union C. Fluorescence Probe Studies on Cyclodextrin Polymers. $25,000

**Karl R. Wirth,** Macalester C. Origin and Evolution of Intra-Arc Basins Along the Philippine Strike-Slip Plate Margin. $25,000

**Patty Wisian-Neilson,** Southern Methodist U. Reactions of Low-Coordinate Phosphorus Compounds with New Phosphido-Bridged Diiron Anions. $25,000

**Phillip A. Zoretic,** East Carolina U. A Radical Approach to Diterpenes. $25,000

## ACS-PRF Grants for Fundamental Research in the Petroleum Field (Type G)

### Awarded to faculty in Ph.D.-granting departments

**Maria A. Barrufet,** Texas Engineering Experiment Station. Determination of Partition Coefficients, Density and Viscosities of Brines/$CO_2$/Hydrocarbon Systems Using NMR. $20,000

**Kay M. Brummond,** West Virginia U. A Novel Intramolecular 1,3-Dipolar Cycloaddition Using a Sulfine and Its Application to the Synthesis of Antitumor Antibiotic Sarkomycin. $20,000

**Vincent J. Catalano,** U of Nevada, Reno. Square Planar $d^8$ Transition-Metal Complexes and Their Application in Stabilized Multiple Metal-Metal Bonded, Donor-Acceptor Complexes. $20,000

**William E. Crowe,** Emory U. Catalytic Allene Activation by Transition Metal "Heteroatoms". $20,000

**Stephen G. DiMagno,** U of Nebraska, Lincoln. New Mixed Valence Materials. $20,000

**Ulrike Diebold,** Tulane U. Study of Metal Nanoclusters on Surfaces of Metal-Oxide Thin Films. $20,000

**Mark D. Distefano,** U of Minnesota, Minneapolis. Design of Regioselective Reaction Catalysts Based on Fatty Acid Binding Protein. $20,000

**Julie L. d'Itri,** U of Pittsburgh. Utilization of Waste Emission Streams from Stationary Power Sources for the Production of Fuels and Chemicals. $20,000

**Felicia A. Etzkorn,** U of Virginia. Conformationally Constrained Mimics of Helix-Loop-Helix DNA-Binding Proteins. $20,000

**Christine E. Evans,** U of Michigan. Fundamental Studies of Interfacial Interactions. $20,000

**Brian G. Fox,** U of Wisconsin, Madison. Definition of the Reactivity of Toluene-4-Monooxygenase: A New Type of Iron-Oxo Enzyme that Hydroxylates Alkanes, Alkenes, Aromatics, and Halogenated Hydrocarbons. $20,000

**Steven H. Frankel,** Purdue U. A Computational Investigation of Turbulent Nonpremixed Flame Dynamics. $20,000

**James A. Glazier,** U of Notre Dame. Evolution and Rheology of Three-Dimensional Foams. $20,000

**Clare P. Grey,** State U of New York, Stony Brook. Study of Acid Catalysts Using Double and Triple Resonance Solid-State NMR Spectroscopy. $20,000

**Michael M. Haley,** U of Oregon. Cyclophynes: A New Class of Highly Unsaturated Hydrocarbons. $20,000

**Richard C. Holz,** Utah State U. NMR Spectroscopy as a Probe of Dicopper(II) Centers. $20,000

**Michael D. Johnson,** New Mexico State U. Exploration of the Fundamental Chemistry of the Ferrate Ion $FeO_4^{2-}$. $20,000

**Stephen E. Johnson,** U of Iowa. Synthetic Approaches to Molecular Networks Comprising Main Group Elements and Alkyne Units. $20,000

**Wayne E. Jones Jr.,** State U of New York, Binghamton. Electrochemical Investigations of Transition-Metal Radicals by Phase Modulated Voltammetry (PMV). $20,000

**Zhao Kang,** New York U. Stabilization of Sulfonium Ions for Diastereoselective Glycosylation and Potential Application to Solid Phase Chemistry. $20,000

**Piotr Kaszynski,** Vanderbilt U. Dative Bonds in Liquid Crystals. $20,000

**Bruce J. Kellett,** U of Cincinnati. Microstructures of Minimum Interfacial Energy. $20,000

**Paul E. Laibinis,** Massachusetts Inst. of Technology. Use of Covalently Incorporated Silsesquioxanes in Polymeric Networks. $20,000

**Gustavo Larsen,** U of Nebraska, Lincoln. Electrochemical Promotion in Catalysis: Hydrogenation Reactions and Surface Characterization of a Pt/$Cs^+$-β" Alumina/Ag Solid Electrolyte Cell. $20,000

**Randy W. Larsen,** U of Hawaii, Manoa. Conformational Dynamics of Intermolecular Electron Transfer in Proteins. $20,000

**David S. Leigh,** U of Georgia. Image and Isotope Analysis of Opal Phytoliths in Sedimentary Sequences. $20,000

**Andrea J. Liu,** U of California, Los Angeles. Theoretical Study of Surface Preferential Attraction in Polymer Systems. $20,000

**Peter J. Ludovice,** Georgia Inst. of Technology. Application of Structure-Specific Molecular Models to Polyvinylchloride. $20,000

**Glenn J. Martyna,** Indiana U. Manybody Quantum Dynamics of Molecular Clusters, Liquids and Solids. $20,000

**Patricia A. Maurice,** Kent State U. Secondary Phase Formation During the Dissolution of Aluminosilicates: An Integrated Approach to Reactivity at the Mineral/Water Interface. $20,000

**Alex S. Mayer,** Michigan Technological U. Characterization of a Large Fault Zone as a Barrier to Fluid Flow: San Andreas Fault Near Desert Hot Springs, California. $20,000

**Mark C. McMills,** Ohio U. Metallocarbenoid Intermediates as Useful Tools for Tandem Reactions in Synthesis. $20,000

**Anne-Frances Miller,** Johns Hopkins U. Superoxide Dismutase: Electrostatic Redox Tuning in Metalloenzymes. $20,000

**Karl T. Mueller,** Pennsylvania State U. Solid-State NMR Evidence for a Helical Conformation of Lignin. $20,000

**Daniel Neuhauser,** U of California, Los Angeles. Very Short Range Imaginary Potentials: A Tool for Eliminating Anomalies in Molecular Scattering. $20,000

**Ludwig C. Nitsche,** U of Illinois, Chicago. Nonlinear Hydrodynamic Drift Effects in Microporous Transport of Colloids and Macromolecules. $20,000

**Brooks H. Pate,** U of Virginia. Eigenstate-Resolved Correlation Spectroscopy: A Probe of Vibrational Energy Transfer Through Nonbonded Interactions. $20,000

**Robert S. Pilato,** U of Maryland, College Park. Catalysis by Molybdenum Cofactor Models. $20,000

**Jeffrey P. Raffensperger,** U of Virginia. Numerical Modeling of Coupled Groundwater Flow, Heat Transport, and Reactive Solute Transport with Application to Diagenetic Cementation by Free Convection. $20,000

**Carmelo J. Rizzo,** Vanderbilt U. Controlling the Redox Chemistry of Flavins Through Conformational Effects. $20,000

**Karin Ruhlandt-Senge,** Syracuse U. Synthesis, Structure and Reactivity of Alkaline-Earth and Organoalkaline-Earth Derivatives. $20,000

**Steven S. Saavedra,** U of Arizona. Molecular Ordering in Hydrated Protein Films Formed by Site-Directed Immobilization. $20,000

**Yeon-Kyun Shin,** U of California, Berkeley. A Molecular Description of Signal Transduction. $20,000

**Masoud Soroush,** Drexel U. A Study of Nonlinear State Estimation and Control Issues in Polymerization Reactors. $20,000

**Richard J. Spontak,** North Carolina State U. Morphological and Phase Studies of $(AB)_n$ Multiblock Copolymers Near the Order-Disorder Transition. $20,000

**Gilbert C. Walker,** U of Pittsburgh. Infrared Pump/Probe Studies of Protein Conformational Change. $20,000

**Peter J. Whiting,** Case Western Reserve U. Validation of a More Appropriate Model of Near-Bed Flow and Resistance Over Mixed-Size Beds. $20,000

**Angus P. Wilkinson,** Georgia Inst. of Technology. Potential Shape Selective Reducing Agents: Microporous Materials Containing Extra-Framework Gallium(I). $20,000

**Karen L. Wooley,** Washington U. Preparation and Characterization of Water-Soluble Nanoscale Polymer Assemblies: Permanent, Micellar Small Particles. $20,000

**Omar M. Yaghi,** Arizona State U. Crystalline Microporous Chalcogenides from Molecular Cages. $20,000

**David J. Yaron,** Carnegie Mellon U. Electron Correlation and the Nonlinear Optical Properties of Polyacetylene. $20,000

**Zijian Zeng,** U of Hawaii, Manoa. Developing Chemical Agents Hydrolyzing DNA Phosphate Backbone. $20,000

## Awarded to faculty in non-Ph.D.-granting departments

**Gretchen L. Anderson,** Indiana U, South Bend. Interaction of Arsenite with Arsenite Oxidase, a Molybdenum Hydroxylase. $20,000

**Paul F. Brandt,** Western Carolina U. Synthesis of Ferrocene-Phosphorus Polymers. $20,000

**S. Keith Dunn,** Centre C. Electronic Energy Transfer from Alkali Halide Substrates to Adsorbed Molecules. $20,000

**David C. Easter,** Southwest Texas State U. Production, Characterization, and Formation Dynamics of Environmentally Destructive Solvation Clusters. $20,000

**Michael R. Gross,** Florida International U. Fracture Partitioning in Mechanically Layered Rocks. $20,000

**Michael E. Ketterer,** John Carroll U. Electron Self-Exchange Rates of Ni(III/II) Redox Couples Measured by Enriched Stable Isotope Labeling Procedures. $20,000

**Santanu Khataniar,** U of Alaska, Fairbanks. Viscous Fingering and Effect of a Third Hydrocarbon Phase on Displacement of West Sak Oil by $CO_2$. $20,000

**Jian Ma,** Amherst C. Adsorption Study of the Microstructure of Sedimentary Rocks. $20,000

**Mary M. Mader,** Grinnell C. A-Silylacetyl Oxazolidinones as Versatile Precursors to Optically Active Polyols. $20,000

**Anna Ploplis Andrews,** C of Wooster. Structural Characterization of Connected Polymer Networks. $20,000

**Michael H. Schmidt,** California State U, San Marcos. Investigations of the Peptide-Mediated Synthesis of Nanometer Semiconductor Crystallites. $20,000

**Richard L. Sedlock,** San Jose State U. Field-Based Investigations of Mesozoic Rocks Near El Arco, Central Baja California, Mexico. $20,000

**Shannon L. Studer,** C of Charleston. Molecular Design and Photodynamic Study of Proton/Charge Transfer Molecules. $20,000

**Nongjian J. Tao,** Florida International U. Surface Charge Induced Structural Phase Transitions of Monolayer Organic Films at Solid-Liquid Interfaces. $20,000

**Vladimir Tsukruk,** Western Michigan U. Molecular Films from Discotic Liquid Crystals and Polymers. $20,000

**Dean A. Waldow,** Pacific Lutheran U. Nuclear Magnetic Resonance Measurements of Local Segmental Dynamics of Polymer Blends in Solution. $20,000

## ACS-PRF Grants for Fundamental Research in the Petroleum Field (Type SE)

**Ken B. Anderson,** John C. Crelling, on behalf of ACS Division of Geochemistry, Inc. Amber, Resinite, and Fossil Resins at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Peter B. Armentrout,** on behalf of ACS Division of Physical Chemistry. Metal-Metal Bonding: From Clusters to Surfaces at the 209th ACS national meeting, Anaheim, Calif., April 1995. $2,000

**Christine A.B. Brennan,** on behalf of ACS Education Division. ACS Project SEED Supplementary Program. $25,500

**David Chandler,** Robin M. Hochstrasser, on behalf of ACS Division of Physical Chemistry. Coherence in Condensed Phase Reactions at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**James V. Crivello,** on behalf of ACS Division of Polymeric Materials: Science and Engineering, Inc. UV Curing of Coatings at the 209th ACS national meeting, Anaheim, Calif., April 1995. $2,000

**Burtron H. Davis,** George D. Blyholder, on behalf of ACS Division of Colloid & Surface Chemistry. Infrared Studies of Surface and Adsorbed Species, in Honor of Dr. Eischens, at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Thomas D. Demchuk,** on behalf of Coal Division, Geological Society of America. Origin of Compositional Characteristics in Tertiary Coals: Paleoecology, Paleobotany, and Palynology at the Geological Society of America Annual Meeting, Seattle, October 1994. $2,000

**Barry L. Farmer,** on behalf of ACS Division of Polymer Chemistry, Inc. Computer Modeling of Polymers in the Solid State at the 209th ACS national meeting, Anaheim, Calif., April 1995. $2,000

**Warren T. Ford,** on behalf of ACS Division of Polymer Chemistry, Inc. Chemical Reactions in Polymeric Environments at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Richard D. Gilbert,** on behalf of ACS Division of Cellulose, Paper & Textile. Order in Cellulosics at the 207th ACS national meeting, San Diego, March 1994. $2,000

**John A. Gladysz,** on behalf of U of Utah. Organometallic Chemistry at the Joint 50th Northwest Regional and 12th Rocky Mountain Regional ACS Meeting, Park City, Utah, June 1995. $2,000

**John A. Gladysz,** on behalf of U of Utah. Metal Complexes of Carbon: Coordination Chemistry of $C_n$ Ligands at the 1995 International Chemical Congress of Pacific Basin Societies, Honolulu, December 1995. $2,000

**Anthony Guiseppi-Elie,** on behalf of ACS Division of Polymeric Materials: Science & Engineering, Inc. Transducer Active Polymers: Active Components in Sensors and Actuators at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**C. David Gutsche,** on behalf of Texas Christian U. Third International Conference on Calixarenes and Related Compounds, Forth Worth, Tex., May 1995. $2,000

**Kathleen O. Havelka,** on behalf of ACS Divs. of Polymer Chem., Inc.; Polymeric Materials: Sci. & Eng, Inc. Electrorheological Materials and Fluids at the 208th ACS national meeting, Washington, D. C., August 1994. $2,000

**Brian B. Laird,** on behalf of ACS Division of Physical Chemisty. Density-Functional Theory in Chemistry at the 209th ACS national meeting, Anaheim, Calif., April 1995. $2,000

**Ripudaman Malhotra,** on behalf of ACS Divisions of Fuel Chemistry and Petroleum Chemistry, Inc. Hydrogen Transfer in Hydrocarbon Processing at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Thomas E. Mallouk,** on behalf of ACS Division of Colloid & Surface Chemistry. Chemical Sensors and Interfaces at the 209th ACS national meeting, Anaheim, Calif., April 1995. $2,000

**C. Mathew Mate,** on behalf of ACS Division of Colloid & Surface Chemistry. Molecular Tribology at the 209th ACS national meeting, Anaheim, Calif., April 1995. $2,000

**Munmaya K. Mishra,** on behalf of ACS Division of Polymer Chemistry, Inc. Polymers for the Oil Industry at the 207th ACS national meeting, San Diego, March 1994. $2,000

**Alan I. Nakatani,** on behalf of ACS Division of Polymeric Materials: Science & Engineering, Inc. Flow-Induced Structures in Polymers at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Raphael M. Ottenbrite,** on behalf of ACS Division of Polymer Chemistry, Inc. Biorelated Polymers at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Umit S. Ozkan,** Harold H. Kung, on behalf of ACS Division of Colloid & Surface Chemistry. Catalysis and Photocatalysis Over Oxides at the 210th ACS national meeting, Chicago, August 1995. $2,000

**Daniel J. Pasto,** on behalf of U of Notre Dame. 25th Reaction Mechanisms Conference at the U of Notre Dame, Notre Dame, Ind., June 1994. $2,000

**A. G. Requejo,** on behalf of ACS Division of Geochemistry, Inc. Quantitation in Organic Geochemistry: Applications and Perspectives at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Martin A. A. Schoonen,** on behalf of ACS Division of Geochemistry, Inc. Geochemical Transformations of Sedimentary Sulfur at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Arthur W. Snow,** on behalf of ACS Division of Polymeric Materials: Science & Engineering, Inc. Polycyanates: Chemistry and Applications at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Jan J. Spitzer,** Donald A. McQuarrie, on behalf of ACS Division of Colloid & Surface Chemistry. Double Layer Effects in Colloidal Science: Recent Progress, Fundamental Results, and Experimental Evidence at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Klaus H. Theopold,** William E. Buhro, on behalf of ACS Division of Inorganic Chemistry. Organometallic Chemistry in Materials Science at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Marek W. Urban,** on behalf of ACS Division of Polymeric Materials: Science & Engineering, Inc. International Symposium on Polymer Spectroscopy at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Shi-Qing Wang,** on behalf of ACS Division of Polymer Chemistry, Inc. Interface and Surface in Rheology of Polymers at the 209th ACS national meeting, Anaheim, Calif., April 1995. $2,000

**Jack M. Williams,** on behalf of ACS Division of Inorganic Chemistry. Advances in the Chemistry and Properties of Novel Low-Dimensional and Conducting or Superconducting Solids at the 1995 International Chemical Congress of Pacific Basin Societies, Honolulu, December 1995. $2,000

**Loren D. Williams,** on behalf of American Crystallographic Association. New Trends in Small Moiety Crystallography at the 1994 American Crystallographic Association Annual Meeting, Atlanta, June 26–July 1, 1994. $2,000

**R. Stanley Williams,** on behalf of ACS Division of Physical Chemistry. Materials Research at the Crossroads of Physical and Solid-State Chemistry at the 208th ACS national meeting, Washington, D.C., August 1994. $2,000

**Erwin L. Zodrow,** on behalf of U C of Cape Breton. Paleobotany and Coal Science: Euramerican Carboniferous Paleobotany at the 1st Walter A. Bell Memorial Symposium, Sydney, Australia, May–June 1995. $2,000 □